AMERICAN MACHINIST

August 23, 1939

Broken Bottlenecks—*This Cincinnati shaper, machining a die for forming airplane-fuselage channel sections, is typical of how modern machine tools eliminate restricted shop production (page 627).*

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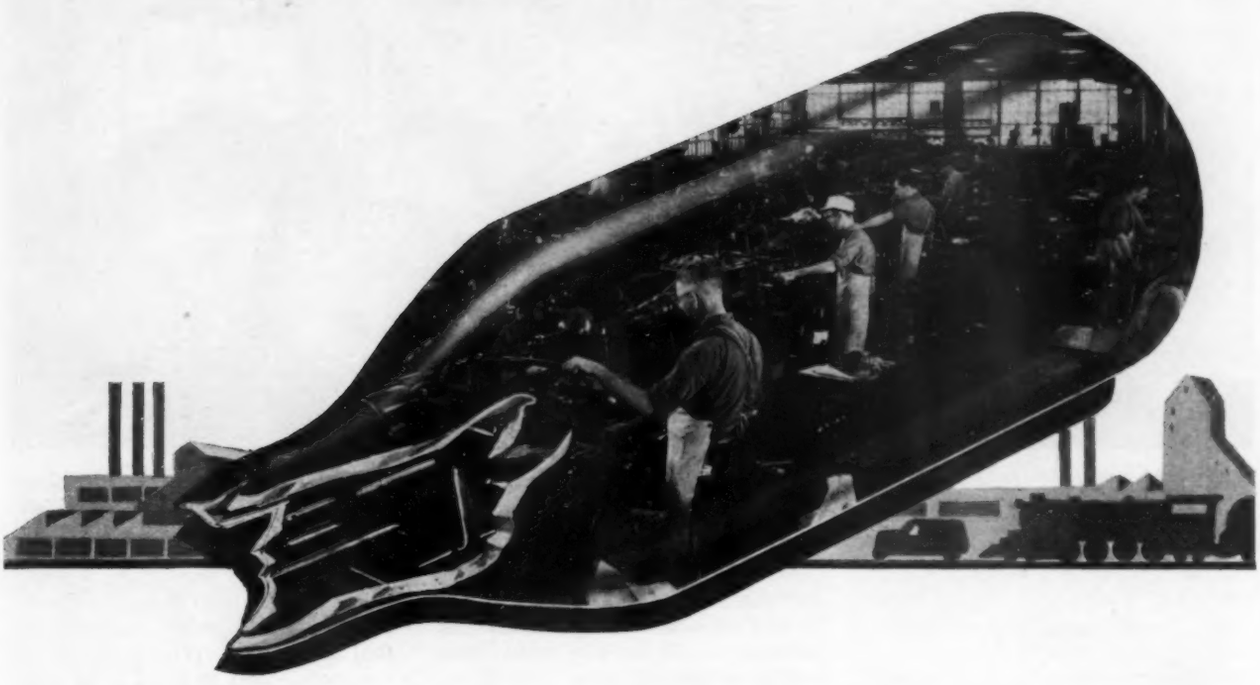
A COMPLETE GUIDE to the Machine Tool Show

★ ★ ★

★ A visit to the Machine Tool Show this fall will be productive in the application of new ideas and methods to your own plant. *American Machinist* will make this visit more productive with a preview of the Show in its September 20 issue. ★ A floor plan of the exposition and a complete list of exhibitors will direct you quickly and efficiently to exhibits of interest. The "Show in Print" section will describe new machines and equipment to be shown for the first time at the Show. Advertising pages too will detail equipment and supplies to be shown. You will find a complete guide to the Show in the September 20 *American Machinist.*

Coming Sept. 20 • Machine Tool Show Number • American Machinist

ESTABLISHED 1877 **AMERICAN MACHINIST** BURNHAM FINNEY, Editor



Broken Bottlenecks

RECENTLY there appeared on these pages (*AM*—Vol. 83, page 511) an account of four case histories concerning bottlenecks in metal-working plants. In each case, an unbalance in manufacturing facilities was encountered which restricted production until it was removed. The methods used to break the bottlenecks were described, together with the incidental advantages that resulted.

Here are some more broken bottlenecks. The case history pattern of presentation is followed as in the previous article. Each case is a story in itself, and each story is suggestive of plant improvements that may be used to solve similar problems.

ELECTRICAL PRODUCTS

THE JOB. Set up to produce screw machine parts for all of the divisions at the Westinghouse Electric & Manufacturing Company's East Pittsburgh plant, the Feeder Division's screw machine department necessarily must be able to produce a wide range of products from practically all of the materials that can be handled in screw machines and turret lathes. In this department there are more than 50 single-spindle automatics and about fifteen multiple-spindle automatics which range up to 3½-in. diameter stock capacity. The turret lathes also located in this department have the same range of capacity.

Since production requirements are such that a normal month may see as many as 7,000 individual orders going through the department, each of these orders calling for from 1 to 5,000 pieces, it is easy to understand that the production set-up must be flexible as well as highly efficient. As many as four to five million pieces may be produced in an average normal month.

THE BOTTLENECK. Over a period of time, not only have the requirements for type of products changed, but quality requirements have been made increasingly stringent, with constant demands being made upon this department for holding work to closer tolerances and for the production of better finishes.

The layout of the department gradually became inefficient because of changes in production requirements, forcing considerable back-tracking of production flow lines. Also, the production equipment became obsolete, making it difficult to meet quality and accuracy requirements. New products requiring a large number of screw machine parts were placed on the market by Westinghouse and the screw machine department found it increasingly difficult to keep the production rate at a proper level and still keep down manufacturing costs.

THE REMEDY. Many factors had to be considered in evolving the remedy for a condition that had gradually grown worse with the passage of years and a complete rearrangement of the department was determined as the best solution. By discarding a large number of obsolete machines and purchasing 35 new high-speed single-spindle automatics, two multiple-spindle automatics, and 14 tur-

Thirty-five new high-speed single-spindle automatics augment the productive capacity of this group and permit the manufacture of parts to closer tolerances. An improved lighting arrangement eliminates shadows around these machines

ret lathes, as well as having six turret lathes reconditioned at the manufacturer's plant, it was possible to set up the department on two floors, instead of the three previously occupied, and still provide a twenty per cent increase in productive capacity. There now are fifteen per cent fewer machines on the two floors than previously were on the three occupied. A modern lighting installation has improved working conditions in the department.

By grouping the machines and arranging them for proper production flow, major economies have been effected. Now all of the automatics are located on one floor of the building, together with a second operation group, oil recovery centrifuges where oil is recovered from the chips, and a cleaning machine which removes all traces of oil and dirt from the finished parts before they are inspected and shipped. All turret lathes and another second-operation group is located on a second floor, where the short-order group also has been placed. This short-order group has been one of the major factors in eliminating bottlenecks in this department.

In this group, which is responsible for all orders requiring from one to five pieces, there are a number of lathes, milling machines and drill presses. By separating these orders from normal production orders, manufacturing economies are effected because of savings in time required for changing set-ups on high production machines. When it is considered that 30 per cent of the individual orders going through this department now are routed to the short-order group it is understandable that a bottleneck condition could develop when these orders necessarily were placed on high-production units. Red tape has been practically eliminated in the operation of this group, the regular production control system being short-circuited.

In order further to eliminate lost time in keeping the high production equipment running, all standard tools regularly used have been moved to the floor instead of being kept in the tool crib. For instance, sets of collets and standard tool holders now are placed in racks beside the individual machine and each operator is furnished a supply of drills and cutters. These cutting tools regularly are returned by the group leader to the tool room for sharpening and, except for special tools required for a given job, the individual operators and set-up men seldom find it necessary to make a trip to the tool crib.

In order further to facilitate production, first piece inspection no longer is required on small lots, this practice being confined to quantities of more than 25 pieces. For such smaller lots, the operator is held responsible for first piece inspection. It is considered more economic to have first piece inspection on the larger lots, however, as any loss because of inaccuracies multiplies rapidly on the high-speed machines now installed.

FUSELAGE FORMING DIES

THE JOB. The Atlantic Manufacturing Company produces dies for forming 0.020–0.070 in. duralumin channel sections for aircraft fuselages. These are of various circular shapes up to 36 in. long; two, three or four different pieces, each carrying a part of the shape, are riveted together to form a complete oval. The fuselage is made up of a number of these ovals tied together with longitudinal strips. It is over this framing that the skin of the ship is applied. The outside flange of each channel-shaped section is tapered in order to accommodate the shape of the ship, which taper varies from 0 to 20 deg. open bevel. Therefore, to machine the punches and die walls, it is necessary to create a constantly changing bevel from one end of the die to the other.

THE BOTTLENECK. The punches and dies are made of tank steel, flame cut to approximate shape, annealed, and surface ground top and bottom by the Lukens Steel Company. Upon arrival at the machine shop, the pieces are treated with steel blue and a line is scribed thereon from a templet to the shape desired. This line is not a regular radius but a complex curve. The bevel required on these pieces is so great that as much as ¾ in. of metal has to be left beyond the templet line when they are flame cut.

The first few orders of these punches and dies were finished on a

milling machine with a circular table. Since the bevel angle changes continually from one end of the piece to the other, the milling machine operator had to set the milling cutter over at the proper angle and follow the templet line a short distance, then set the head over a little further and follow the line until the cutter left it at a tangent; this was continued until the piece was finished. This proved to be a difficult operation inasmuch as the bevel changed on a single punch or die from as much as 2 deg. to 5 deg., to 8 deg., back to 2 deg., and then as much as 20 deg. Milling the bevel not only proved to be tedious and difficult, but it slowed production to the point where the punches and dies could not be delivered on specified dates.

THE REMEDY. A Cincinnati 24-in. heavy-duty shaper, having a universal table which revolves to any angle, was installed to machine the punches and dies. With the swiveling vise on this machine, the work can be rotated around three axes. By setting the pieces in this vise, it is possible to follow the templet line and change the bevel continuously while the machine is running. The operator feeds the cutting head down by hand as the feed on the shaper moves transversely; in addition, he changes the bevel angle of the cut by a slight movement of the crank on the universal table, thereby altering the angle of the work in relation to the cut. It is not necessary to stop the machine provided the length of the piece permits. The operator first takes a roughing cut $\frac{1}{2}$ in. thick, using a 0.040 in. feed. A finishing cut of 1/32 in. is taken at a feed of 0.010 in. and a surface cutting speed of 60 ft. per min.

Dies for forming airplane-fuselage channel sections of irregular shapes and having outside flanges which taper radically are machined easily in this 24-in. heavy-duty Cincinnati shaper equipped with a universal table

OIL BURNER PUMPS

THE JOB. A manufacturer of oil-burner pump bodies found it necessary to manufacture them in short runs of 500 to 1,000 at a time. Since it is a contract proposition for several customers and there are slight changes in dimension for each it is impossible to run steadily on any one job. The business is such that it is impossible to build up stock in slack seasons and it is a practice to keep right in line with month to month delivery requirements of the customer.

THE BOTTLENECK. The necessary turning operations on the pump body were performed in two turret lathes and one engine lathe. The pump-shaft hole was broached and the pump body then placed on an arbor for the final turning operations. The limit of accuracy on run-out with this method of operation was 0.003 in. Since every customer had slightly different dimensions on the shaft housing the set-up in one of the turret lathes had to be changed every time a different order was going through the shop. Sometimes as many as eight set-ups were required per week increasing the cost of production besides making it difficult to keep in line with customer requirements on delivery.

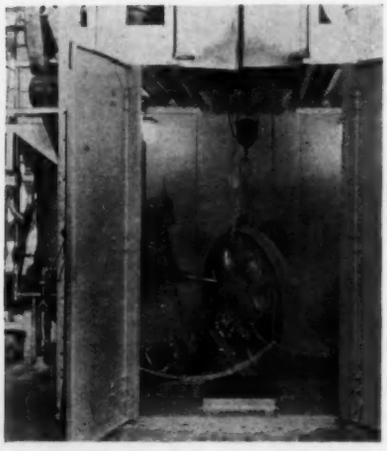
THE REMEDY. A Sundstrand production lathe replaced one of the turret lathes, making the latter available for other production work. A re-arrangement of operations was made possible by using the production lathe because of the change in the method of chucking the work and use of standard attachments. Instead of doing the final turning operations on an arbor, the piece could be chucked on a flat surface which gave improved accuracy and run-out of the shaft was reduced to 0.0005 in. The open end of the housing is rough and finish bored, the inside diameter chamfered and the closed end rough and finish faced and the flange rough and finish faced in one setting in the production lathe. A straight feed-in attachment applied to the front carriage permits the carriage to feed longitudinally, come to a dwell, after which the tool slide feeds crosswise. This makes possible boring the inside diameter and facing the closed end of the housing with the same tool. Approximately $\frac{1}{2}$ in. in the open end requires boring after which the tool has to travel $1\frac{3}{8}$ in. without cutting to reach the back end of the bore. By applying skip feed the distance is covered in rapid traverse at a rate of 250 in. per min. instead of a feed at the rate of 3 in. per min. Total saving in distance for rough and finish cut is about $2\frac{3}{4}$ in. A two-speed motor provided the necessary low and high speeds for rough and finish turning. Total saving in overall machining time is 20 per cent.

This Sunstrand production lathe, installed for machining short runs of oil-burner pump bodies, eliminated set-up changes necessitated by varying dimensions of the pump bodies in different orders, and effected a 20 per cent saving in machining time

Heavy Turning on Locomotive Wheel Centers and Tires

By JOHN HAYDOCK
Managing Editor, American Machinist

Driving wheel centers are steel castings of carbon or alloy steel, depending upon the service conditions to be met. Before any machining is done, castings are annealed in a modern oil-fired furnace, automatically controlled to give uniform heating of the product. This furnace is used for heat treatment after rough machining.

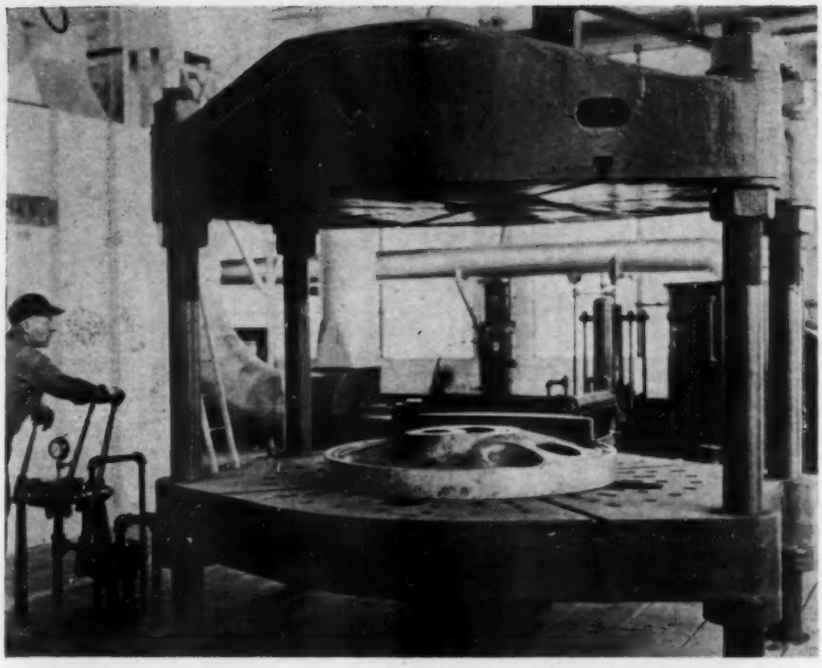


After annealing, scale is removed from the surfaces in a shot blast unit.

STANDARD Steel Works Company, traces its origin to the Freedom Forge which was established at Burnham, Pa., in 1795 and which later became the Freedom Iron and Steel Company. The plant was acquired by William Butcher and Company in 1870, and in 1875 it was taken over by the Standard Steel Works Company, now a wholly owned subsidiary of the Baldwin Locomotive Works.

The company's contributions to the railroad indusry have been many. When it was found necessary to produce its own steel, it installed the first Wellman tilting open hearth furnace, served by an electrically operated charging machine, also the first of its kind. In 1904, Standard Steel Works Company was one of the first in the United States to manufacture solid steel wheels forged from ingots to replace cast wheels. In 1911, it introduced the rolled steel center, placing 500 of these with bolted tires in regular Pullman service.

It is not surprising that an organization with such a tradition of progress should still be active in finding and adopting the most modern methods in its operations. During the past few years, several hundred thousands of dollars worth of new equipment has been installed in its machine shop to rough and finish machine rolled products such as wheels, tires and driving wheel centers for locomotives. This building is 1050 ft. long by 200 ft. wide.



ing is transferred by a roller conveyor to a small special furnace where it is preheated to a satisfactory temperature for the welding operation. The casting is then taken to a special welding booth and repaired by electric welding.

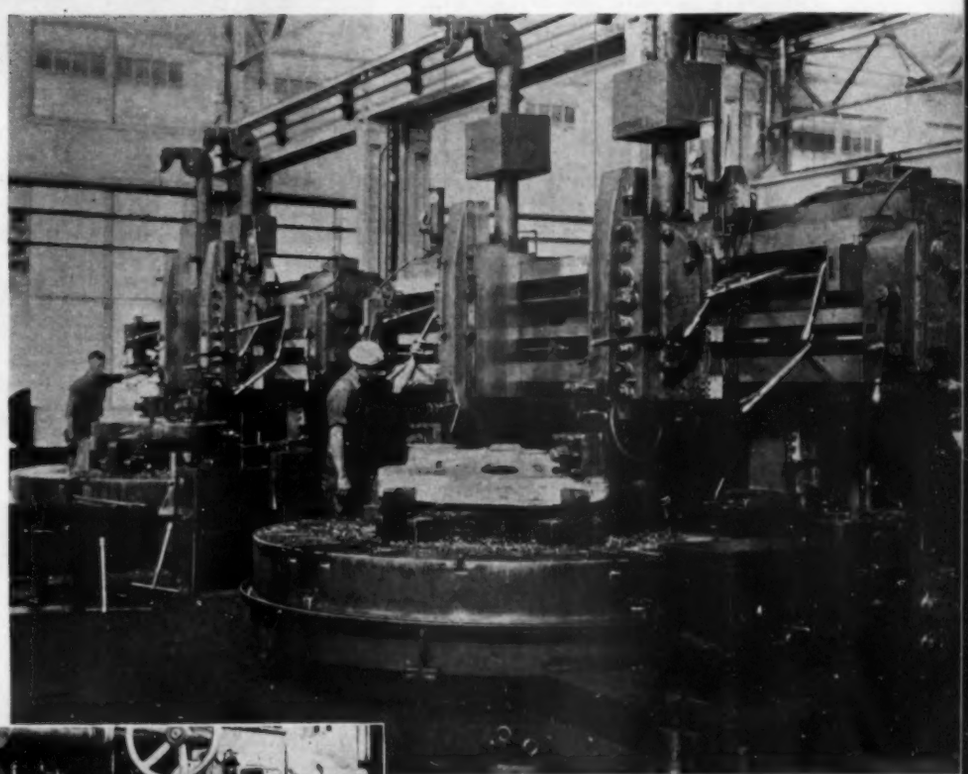
Bore and hub facing is done on two special boring machines built by The Niles Tool Works similar to car-wheel borers but larger. The casting is handled by a crane built into the machine. Five motor driven chuck jaws center the piece automatically. The vertical boring bar is piloted in the table and has two pairs of cutters, one for roughing and one for finishing. The facing bar is fed horizontally through the column with an independent control system. These cutting operations, together with most others in locomotive wheel centers and tires, are done wet. Soluble oil is supplied from a central sump which takes care of several machines at a time.

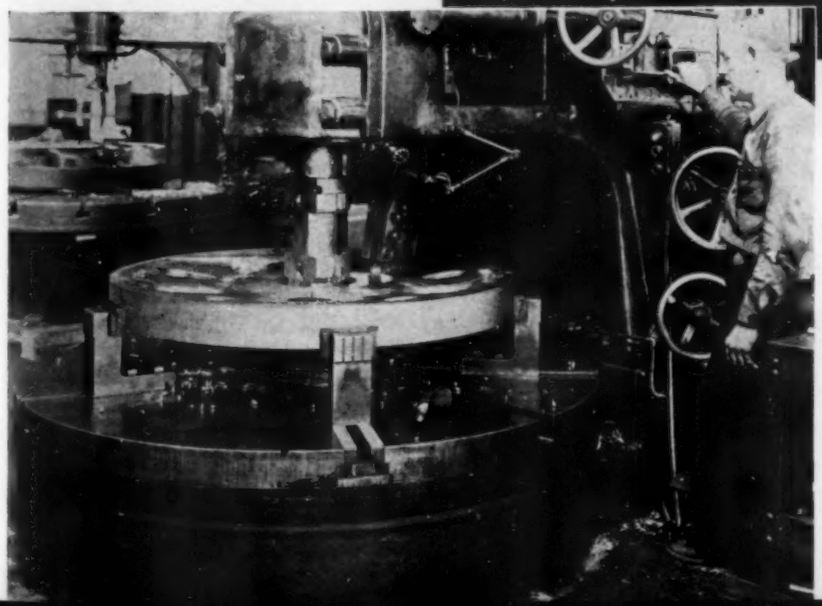
To finish the outside diameter, the centers go to two other machines set up specially for this work. A plug at the center of the table positions the piece accurately from the bore; the plug is turned in place for each new lot of centers so that it is constantly kept true with respect to the machine.

Any distortion, after heat-treatment, is removed by the use of a 250-ton Baldwin-Southwark straightening press.

Five Niles vertical boring mills are used for the first machining operation on wheel centers. These are 118-in. machines with fixed crossrails. The castings are first chucked from the outside, cope side up, to rough turn the rim face and hum. The outer jaws are then moved away while the work is held through the center of the hub to turn the periphery and the under side of the rim. The crank-pin boss and counterbalance are also machined in this set-up. For this machining, as for most operations on wheel centers, high-speed steel tipped tools are used with heavy shanks of 0.70–0.80 carbon steel.

After turning, the centers are given an inspection to note whether any defects that may have been uncovered require welding repairs. If so, the cast-





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HEAVY TURNING ON LOCOMOTIVE WHEEL CENTERS AND TIRES

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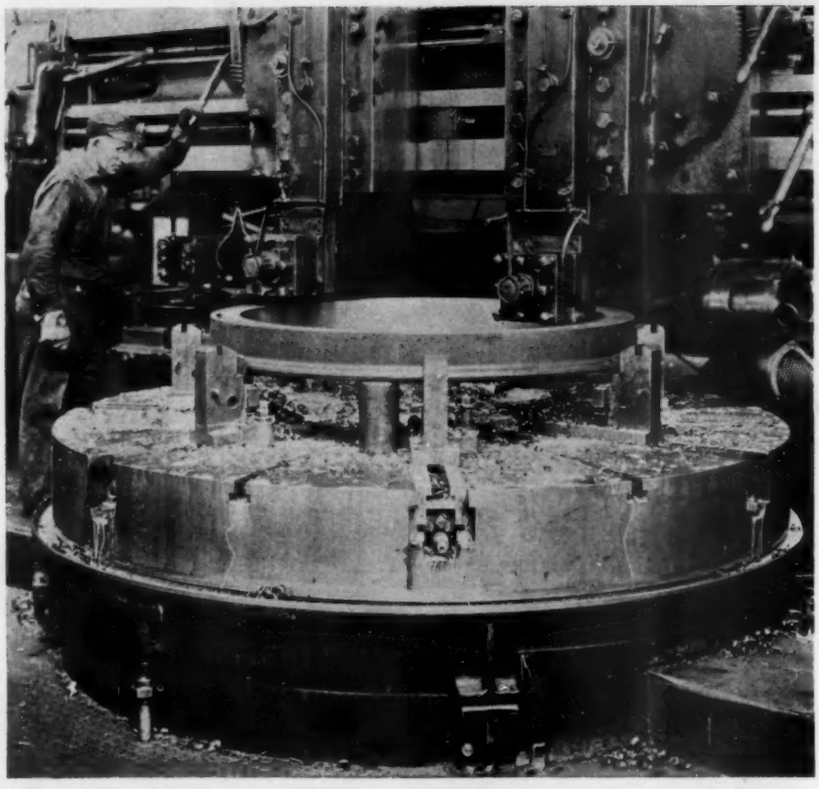
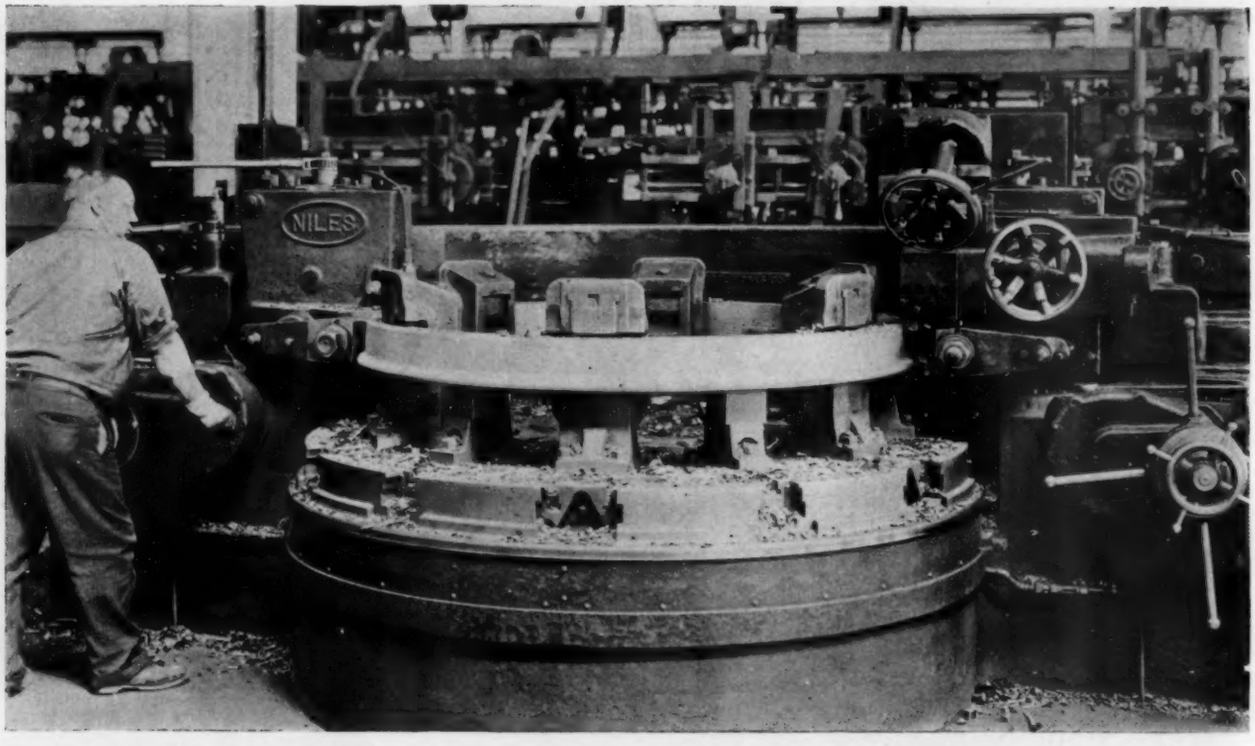


Steel tires for driving wheel centers are forged and rolled from solid ingots by a process developed by the Standard Steel Works through years of experience. Like the centers, the tires are turned on vertical boring mills with fixed rails. Three new Niles mills have been provided for this work recently. The tires are first bored and faced on the inside. Electric chucking is used to set and hold the work in place.



Two new tire turning machines which perform the next step have been designed with an eye to expeditious handling of the work. Tires are mounted on horizontal tables as on the boring mills. There is no cross-rail, but heads on each side of the tire performs the roughing and finishing cuts simultaneously. Tires are centered by motor-driven jaws that support the rough tire from the inside and bottom; clamping is done by an additional set of five hydraulic jaws which move outward over the work and come down to grip the tire with hardened steel inserts. Both cutting heads operate simultaneously; the high-speed cutting tools on this set-up have a cobalt content and are cast to the desired shape, then ground to the required form and degree of sharpness. The use of these specially shaped cutting tools has decreased tool maintenance.

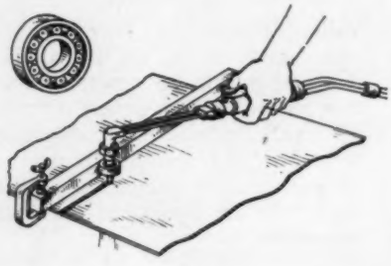
The chief feature of these machines is the rapid chucking. By means of a push button control, which operates two sets of jaws, tires can be unloaded and loaded in less than two minutes from cut to cut.

SHORT CUTS FOR THE SMALL SHOP

A. H. WAYCHOFF

ONE WELDER has found that tightly pushing a small roller bearing assembly on the welding torch nozzle makes a smooth running guide when used against a straight-edge. The bearing is a small one like those found in automobile generators and motors. They make a snug fit on the average torch nozzle, and help a lot in making straight cuts in places where it's possible to hold or clamp a heavy bar to the work for a guide

Roller bearing serves as guide for cutting torch...



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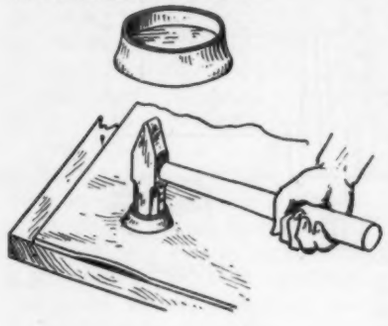
IF YOU WANT to make a soft-face hammer out of your large-face heavy hammer, you can't do much better than to slip a rubber table leg pad over the head. These pads are sold in a wide range of sizes at all furniture stores and are made of tough, long-wearing rubber. One of the proper size will convert any heavy hammer into one of the best all-around rubber mallets you could want for fender, body or other sheet-metal work

Table leg pad makes soft-face hammer...



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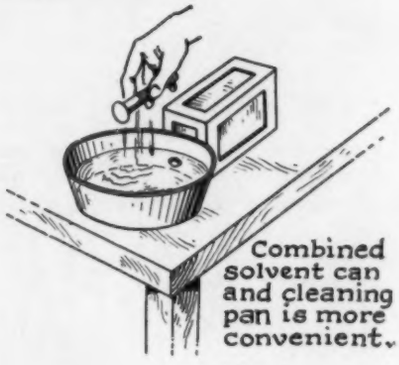
IN USING GASOLINE or other solvent occasionally for washing small parts, the waste is usually considerable. It can be avoided to a large extent by making a container from a small pan and a quart varnish can. This can should be of the type having a metal plug which screws inside the neck. In the pan, cut an opening in one side near the bottom to fit the neck of the can, which is then soldered in place. When not in use, the solvent is kept in the can and the stopper screwed in tightly to prevent evaporation. After removing the stopper, just lay the can on its side and the solvent runs out into the pan. When through, tip the can up slowly and in half a minute all the solvent will be inside the can ready for the stopper again



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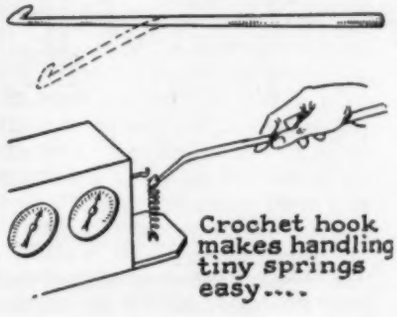
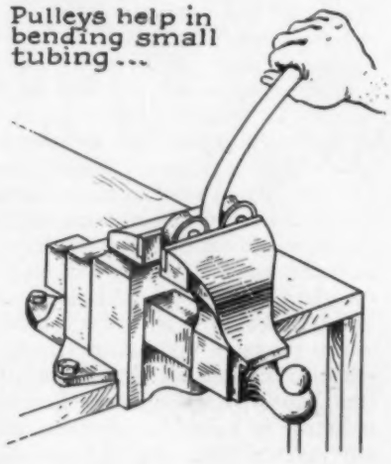
ANYONE WORKING on automobile ignition systems or carburetors and on small machinery such as adding machines, typewriters and cash registers will find a five-cent crochet hook one of the handiest little tools he ever owned. It can be bought at any 5-and-10-cent store and should have about two inches of the hook end bent back at about a 45-deg. angle. In use it is far superior to pliers, tweezers or the fingers for hooking and unhooking the many little coil springs one has to handle when working on small mechanisms



TO MAKE SMOOTH bends in small tubing, try using a couple of small pulleys in the manner shown. They should be exactly alike and the curvature of the groove about the same size and shape as the tubing. In use they are held in the jaws of a vise so they clamp the tubing between them, which then can be bent around either one without any danger of its kinking or flattening

Pulleys help in bending small tubing...



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MACHINISTS having small drill presses in their home shops will find it mighty handy to take a number of common square steel nuts of various sizes and carefully cut them in two across the diameter. These make fine little brackets for holding all sorts of round stock, and greatly lessen the danger of breaking small drills. When used as shown in the sketch, they will hold the work well and prevent it from slipping or turning

Split nuts hold small shafts for drilling...

Drawing Dies

To prevent rupture, when press-forming metals, it is essential to allow a sufficient number of drawing operations and to limit the drawing speed

BY C. W. HINMAN
Tool Engineer
Kobzy Tool & Electric Mfg. Company

DRAWING operations are divided into two classes, "shallow" and "deep". The line of demarcation between the two is naturally fixed at the point where the depth of the draw is less than the diameter, and where the depth may equal or exceed the diameter. The first is used mostly for such products as shallow tinware, shoe-polish and salve boxes, the bottom parts of lamp sockets. These can be made in a single-action press with an inverted die, usually from high brass or tin. A typical die for this class of work, in relatively small sizes, is shown in Fig. 168.

In large work, many difficult parts come under the classification "shallow." The entire turret top of an automobile is made at one blow. Fenders and radiator shells are similarly made. Probably one of the most difficult of these shapes is the front fender with its reverse bends. The difficulties in the way of such large work are identical with those in small deep-drawn work—wrinkles and fracture.

A cup or tube of any length, a form of any shape, and a plastic metal of any description or thickness may be drawn if done in a sufficient number of operations. It may be drawn thinner than the original metal, or it may be thickened up.

In simple bending, the grain of the metal on the outside, or convex surface is stretched beyond its elastic limit, and the crystals slide upon one another. In some metals the crystal structure is "short" or granular, and the crystals will not slide one upon the other sufficiently to allow bending on a short radius. So the metal fractures. Cast iron is a good example of this; antimony is another. Crystalization of some other metals is "stringy", and the flow planes are quite long and definitely perceptible under the microscope. Copper and particularly lead are good examples of this. Such metals will flow easily in any direction. Some metals, such as high brass and Bessemer steel, have short flow lines, but may be made more plastic by rolling into sheets. Low brass and open-hearth steels, on the contrary, have practically no grain, and will flow under pressure in any direction. In a sufficient number of operations, low brass and open-hearth steel can be worked more economically; therefore, they are preferable for certain operations.

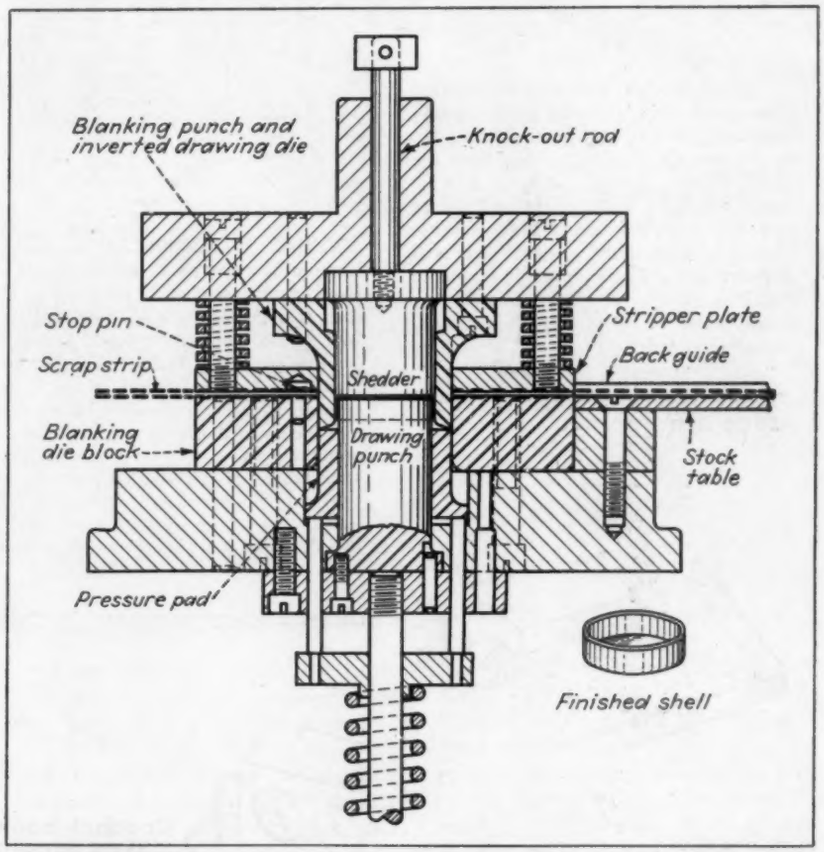


Fig. 168—When drawing shallow box covers, lettering or trade marks can be incorporated by placing stamps or characters in the punch face or shedder

In drawing operations, the forces are largely compressive. There is extensive plastic flow and a violent rearrangement of the crystals in the metal. To illustrate, take a blank 4½ in. in diameter and from it draw a 2 in. diameter cup. First, scribe two parallel lines across the face of the blank, one on each side of the center line, and ½ in. apart, Fig. 169. With the blank held tight enough to prevent wrinkling, lower the press ram so that the punch descends 1 in. below the top of the drawing die, and the shell is drawn 1 in. deep. Upon removal of the shell, the lines will be found still parallel and ½ in. apart across the bottom of the part. Thus, no disturbance has occurred in that area. On the vertical walls, the lines converge toward each other, and at the top are about ⅜ in. apart. On the flange, the lines diverge in opposite directions; they are ⅜ in. apart at the shell walls, and $\frac{7}{16}$ in. apart at the outer edge of the flange.

During the drawing operation, stresses are set up in two directions. Those in the vertical walls are tension stresses, caused by the punch drawing the metal over the edge of the die at nearly right angles against the resistance of the flange to flow. The stresses in the flange, under the pressure pad, are necessarily compressive, caused by the violent effort of a larger area of metal to crowd itself into a smaller area without increasing in thickness or wrinkling. Like a large flock of sheep passing by twos and threes through a narrow opening, there is no trouble in either case unless the operation is hurried. This suggests that drawing punch speeds must be reasonable; the appearance of the first drawn shells usually indicates that a slower punch speed is necessary.

When the shell has been completely drawn, the positions of the lines will be like those in the lower view of Fig. 169. The distance between the lines at the top of the shell is now less than ¼ in., or one-half the original distance. It seems that there should be the same amount of material around the top of the shell as in the periphery of the blank. But is there? No, because a blank circumference of 14⅛ in. has been crowded into one of only $6\frac{9}{32}$ in. around the top of the shell. Where has the extra metal gone? Part of it has been used to build the walls of the shell higher. It will be found by measurement that the area of a blank 4½ in. in diameter is the same as the area of a cup 2 in. diameter by 2 in. deep. This presupposes that the metal has been ironed out to its original thickness. This, in turn, depends upon the physical properties of the metal to withstand the necessary stresses without wrinkling or tearing. It should be remembered that a metal should never be drawn beyond its elastic limit.

If 2×2-in. shell is of good plastic material, it may be annealed and redrawn to another shell, 1½×3 in., and next into a 1×5-in. shell, and finally to a ½×7-in. shell. Shells of these dimensions are made in large quantities for subsequent expanding operations in hydraulic or, more properly, hydrostatic die work.

In designing or making a drawing die, the first thing to remember is

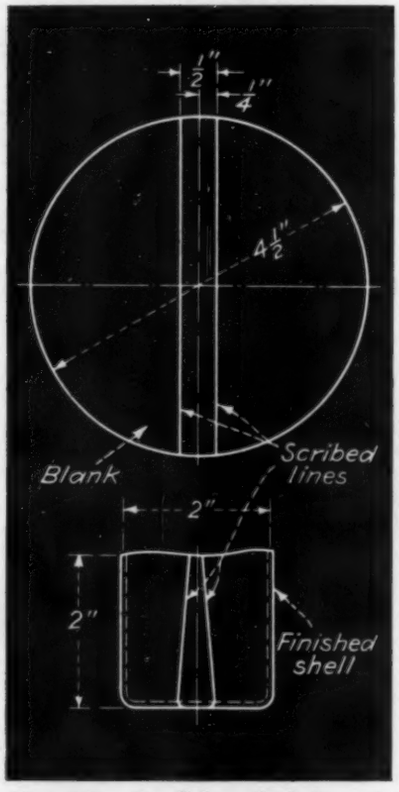


Fig. 169—Parallel scribed lines in the blank will be found to converge from the periphery to the drawing edge, showing that considerable plastic flow must occur if metal is to be made to pass through a constricted space to become a shell

that the shell hugs the punch, and that the size of the punch governs the inside dimensions of the shell. As the punch descends, and the diameter of the flange held by the pressure pad decreases, the shell will hug the punch less tightly at the end of the draw. Where the metal flows over the radius at the top of the die, it is not held at all. Depending upon several factors, this metal may remain smooth, but an examination of most shells will show short wrinkles that have been ironed out under the pressure pad. Being under no drawing tension, this part does not hug the punch so closely. Furthermore, the top is usually thicker than the rest of the shell, because it has not been under drawing tension.

This characteristic of the shell to hug the punch causes trouble in stripping, and is the secondary cause of many accidents. The operator may be running a double-action press continuously, and the finished shells will drop through the press regularly. But a shell may fall to strip, and at the next stroke the press tries to draw two shells at the same time in the same die.

This trouble has led to the design of many types of strippers. Some of them are freakish, some are good. Ordinarily it is not necessary to use a special stripper on metal ⅛ in. or less in thickness. On heavier metal a special stripper is required because the force necessary to strip the shell is greater than the resistance of the top of the shell to shear off against the stripping edge on the die. The need of a stripper is evident here because every shell will come up.

For thin shells, the easiest way to strip the punch is to cut a stripping edge below the drawing edge of the die. This edge should be undercut, and the top of it should be less than 90 deg. with the inner surface of the drawing die, as shown in Fig. 170. The inner surface of the die should be perfectly straight, or even taper inward a trifle, as it approaches the bottom. The metal springs away from the punch slightly at the top of the shell, because it is not under the tension of the pressure pad. After the finished shell is pushed through the die it cannot go back through the same hole when the punch ascends, if there is something to catch against the upper edge of the shell. A stripping edge, Fig. 170, performs the function.

Small shells are sometimes stripped by a floating split ring which is substituted in place of the stripping edge. The ring is of tempered spring steel, and the closed diameter of its hole is about 0.005 in. smaller than the outside diameter of the shell. The drawing punch, in descent, forces the finished shell through the ring, and the ring closes above the shell. When the punch ascends, the shell is stripped off by the ring.

The first precaution to observe in any drawing die, regardless of the type of stripper, is to provide a safety link above the punch, or a key

through it, that will break or shear off when two shells accidently get in the die. The next thing is to note whether the shell came up through the die intact, or whether the upper edge of the shell is nicked. If the former, the die is set eccentric, and the highest part of the shell happened to be at the point of maximum clearance and came up through the opening thus left, and the rest of the shell followed as a matter of course. If the edge of the shell is nicked, the punch needs polishing. The nick indicates that the shell adheres too tightly on the punch. Polishing should always be done lengthwise of the punch. For thin copper shells, crocus cloth should be used in the same manner; a microscope will reveal the reason. The copper, in hugging the punch, is soft enough, and hugs hard enough to enter every tiny cross scratch.

Part 27 of Mr. Hinman's series will appear in an early number.

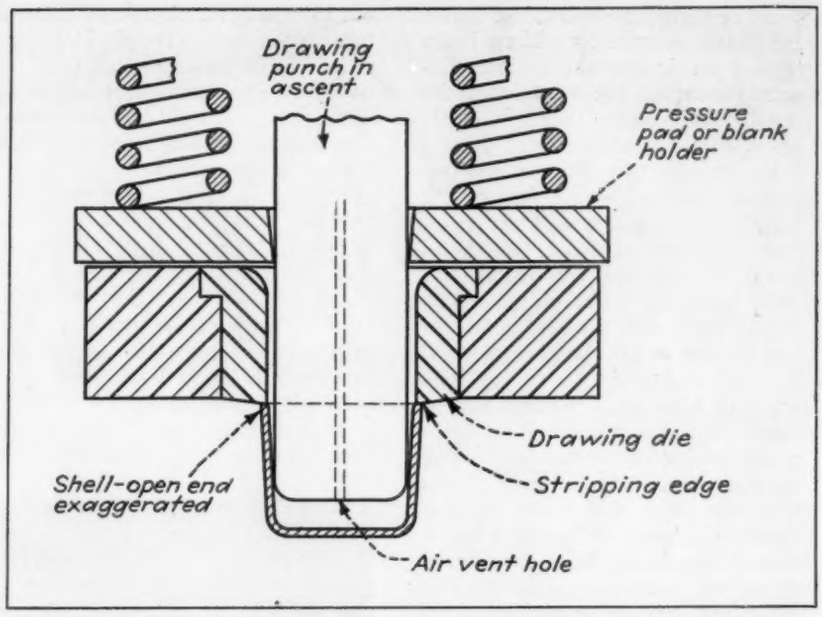
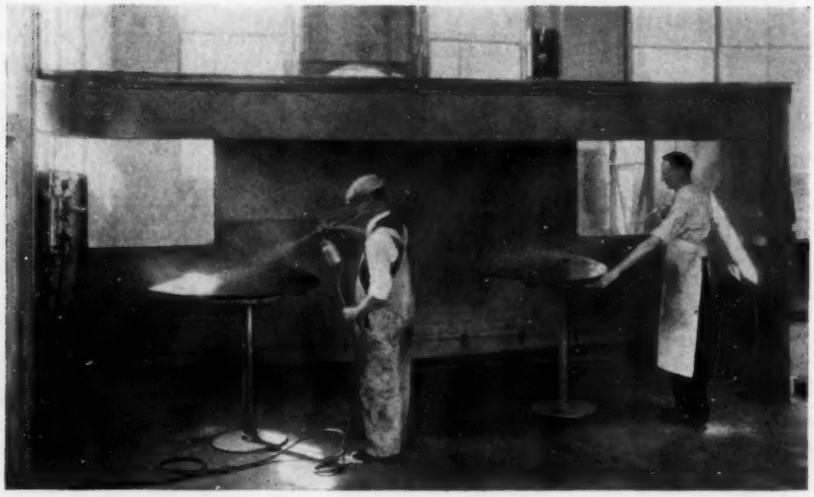


Fig. 170—Since the finished shell can not be pushed back through the same hole when the punch ascends, it is possible to strip the piece by undercutting a stripping edge on the bottom of the drawing ring

Spray Booth for the Small Shop

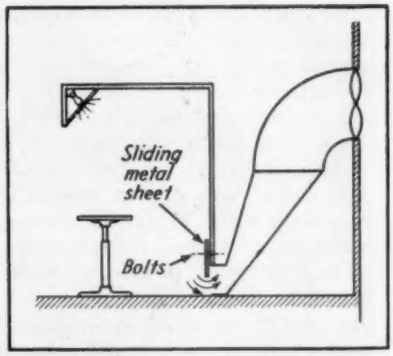


This spray booth at Wright Field replaced a paint room with a three-fan exhaust system

IN ANY shop where an elaborate paint spraying arrangement would be too expensive the spray booth shown in the illustration will do the trick. This was developed at Wright Field where many miscellaneous painting jobs of various sizes are handled. Formerly an inclosed paint room was used and three large fans were required to draw off the fumes. By making this openside booth and rearranging the exhaust system the spray painting needs were fulfilled by using one fan.

Air is drawn from the booth into the exhaust duct through the slot along the bottom of the rear wall. The sheet-metal duct is rectangular in shape tapering up to the circular opening of the pipe elbow. A metal sheet can be moved up and down to control the size of the opening. Control of the air flow in the booth is so good that no respirators are required for any of the spray painting jobs. The booth is lighted by a row of lights with diffusers which are placed along the inside of the upper front edge of the booth. Additional light is provided by windows in the back wall of the booth.

The tables used for spray painting small parts have wood tops mounted on a flanged piece of pipe. The pipe fits loosely in another pipe which is part of the base thus allowing the table to revolve. With this revolving table it is never necessary for the painter to move from his position giving him better control of the work and keeping him out of the air stream. When not in use the spray guns are kept in racks on the side of the booth while the hose can be wrapped on a reel just below the spray-gun supports. Air for spraying is taken from the plant air system through pressure control apparatus.



The booth has a single fan; a variable duct opening controls air flow

Metal-Spraying Technique—II

Courtesy of the Metallizing Engineering Company

METALLIZING can be used to solve many corrosion problems. However, the incorrect use of the process for this purpose will result in costly failures. Therefore, the following factors should be understood before a decision is reached as to which metal should be used for the resistant coating, how it should be applied, the correct thickness and the correct finish.

Sprayed metal is less dense than the same metal in cast form (about ten per cent) and has a definitely porous structure. This porosity is a disadvantage when the coating is to be used to resist corrosion, and unless the pores are sealed the corrosive liquid or gas will penetrate the coating and attack the base material.

In some instances, the porosity of the sprayed metal makes little difference, but in others it is imperative that it be eliminated to obtain satisfactory coating. There are three methods of accomplishing this result. The first is to apply a sufficiently heavy coating to seal up gradually, as each successive layer is applied, any pores which might continue through the entire coat. Since porosity varies with the fineness of atomization of the sprayed metal, thin coats should be applied. Under most circumstances, coatings 0.030 in. thick are considered sufficient.

The second method of eliminating porosity is by mechanically working the metal. Lead, tin and cadmium which are quite soft can be sealed by a thorough wire brushing, using a non-ferrous brush. Harder metals should be ground and polished.

The third method is a chemical treatment with some material or chemical solution which will either physically seal the pores or cause a chemical action which will accomplish this purpose.

When a metal is sprayed, a slight amount of oxide is introduced. While this oxide usually does not affect the uses of sprayed metal, its presence should be kept in mind, and the process not be used when surfaces free from oxide are demanded.

A neutral flame should be used for metallizing. An oxidizing or carburizing flame will slow down the spraying speed and increase cost. When steels are being sprayed an oxidizing flame will lower the carbon content of the sprayed metal, while a carburizing flame will increase the carbon content.

Spraying Non-Metallic Surfaces

Non-metallic materials will not carry away the heat of spraying as rapidly as metallic materials; therefore, they are easily overheated. There is danger that the cooling stresses set-up in the coating will loosen the bond, because the base metal usually has a low strength and dovetails therein are easily broken and torn away. To overcome these bonding difficulties, an undercoat of a metal having a low melting point, such as zinc, tin or lead, should be applied to a thickness of between 0.003 to 0.005 in. Successive coatings of the final sprayed metal should be as light as possible.

SUGGESTED METAL COATINGS TO RESIST CORROSION ON IRON AND STEEL*

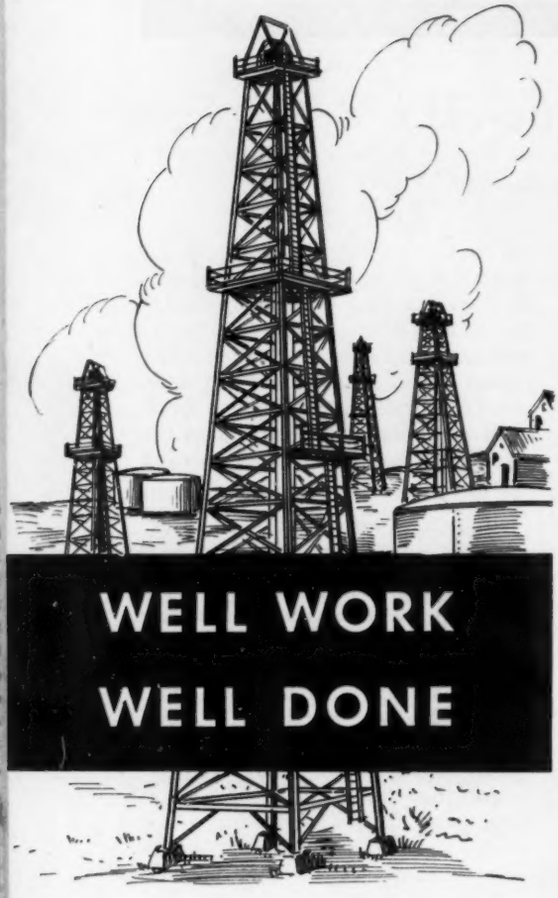
	Anodic to Iron			Cathodic to Iron				
	Aluminum	Zinc	Cadmium	Tin	Lead	Nickel, monel, nichrome	Brasses, bronzes, copper	Stainless steels
Rural and suburban atmospheres	8–10(2)†	6–10(1)†	.....	.....	.....	20–40(x)	30–40(x)	30–40(x)
Mild industrial atmospheres	10–15(3)	10–12(2)	.....	.....	15–25(1)	.....	.....	.....
Heavy industrial atmospheres	15–20(2)	12–15(3)	.....	.....	25–30(1)	.....	.....	.....
Seacoast atmospheres	12–15(3)	10–15(2)	10–15(1)	.....	15–25(4)	30–40(x)	.....	.....
Fresh water, below 100 F	12–15(2)	8–12(1)	.....	.....	.....	.....	.....	.....
Fresh water, above 100 F	12–15(1)	.....	.....	20–30(2)	.....	.....	30–40(x)	.....
Seawater and brines	12–15(4)	10–15(2)	10–15(1)	.....	25–30(3)	40–50(x)	.....	.....
Mild alkaline solutions	.....	.....	10–15	.....	.....	.....	.....	.....
Food products and oils	12–15(2)	10–15(3)	.....	20–30(1)	.....	30–50(x)	.....	30–50(x)
High temperatures, above 1200 F	See Note *A*	.....	.....	.....	.....	.....	.....	.....
High temperatures, below 1200 F	6–8	.....	.....	.....	.....	.....	.....	.....
Mild corrosion	8–15	6–10	10–15	20–30	15–25	30–40	30–40	30–40
Aggravated corrosion	15–25	15–25	15–25	30–50	25–50	40–50	40–50	40–50
Glass reflective surfaces	4–8	.....	.....	.....	.....	.....	.....	.....
Decorative effects	8–20	.....	.....	10–30	.....	10–30	10–30	.....

* Thicknesses of coatings are given in thousandths of an inch.

† Numbers in parentheses indicate general preference; (1) first, (2) second, etc. Actual choice depends on local conditions and economic factors. (x) indicates not generally recommended; should be used in special cases only.

NOTE *A:* Surfaces subject to temperatures exceeding 1,200 F. should be "Alumetized," a process of applying aluminum to an iron or steel base and subsequently heat-treating to produce an alloyed coating of aluminum-iron.

All coating of metals cathodic to iron must be non-porous to afford corrosion protection to the iron or steel base.

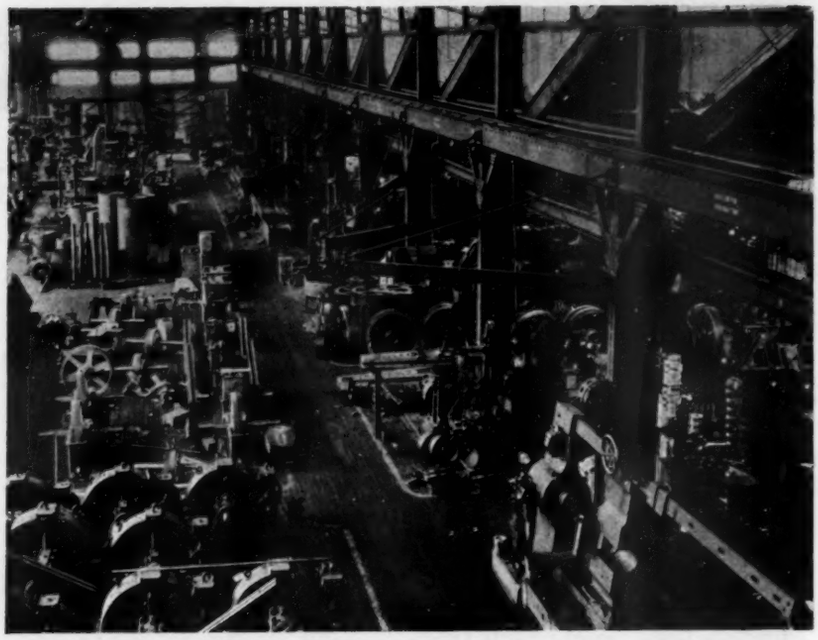


WELL WORK WELL DONE

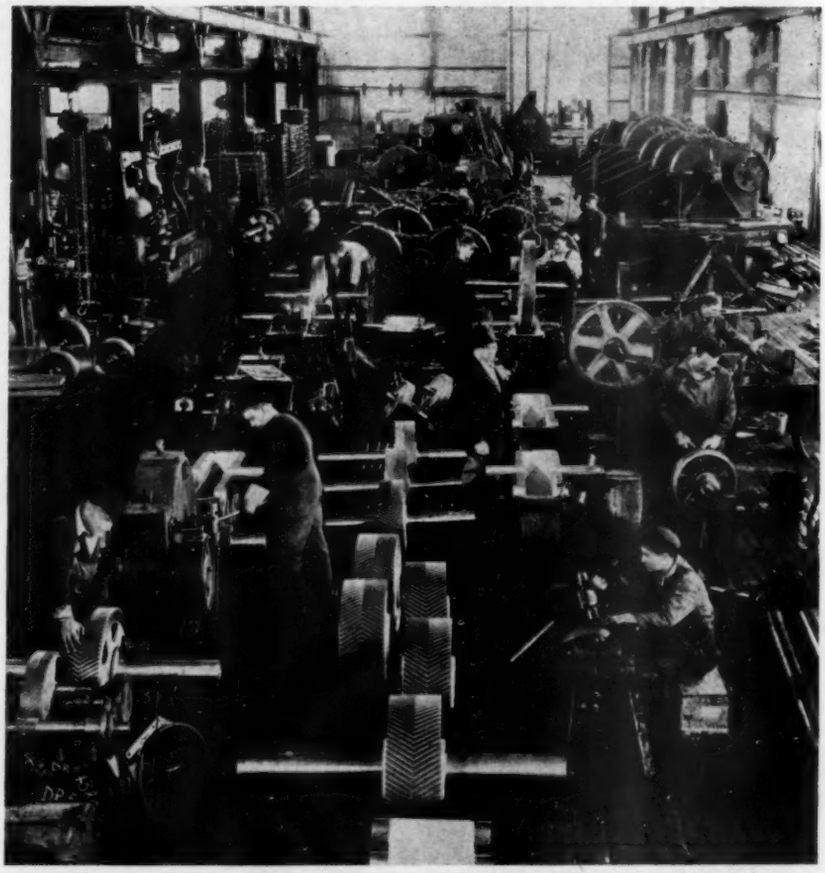
I—A few typical operations on oil-field equipment exemplify the development of an industry that has grown from holes in the ground

By FRED H. COLVIN
Editor Emeritus, American Machinist

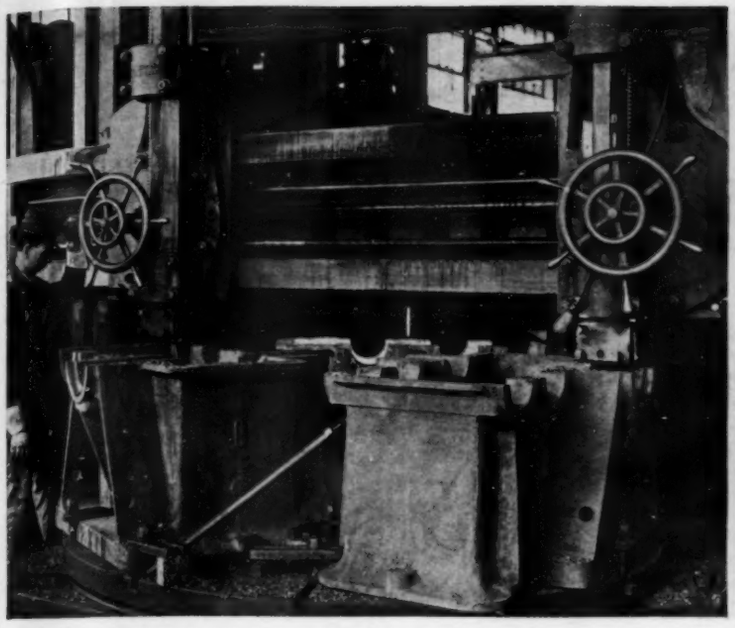
UNLESS one has traveled in the oil country and kept pace with the changes in the oil fields, he will be surprised to find large and modern plants devoted to the building of new equipment necessary for economical oil production. An excellent example is the Lufkin Foundry & Machine Company, which builds pumping jacks and other oil-field equipment. The shop is modern in every respect and is equipped with the latest type machine tools. A few of the machining and assembly operations of the Lufkin plant are shown in the illustrations.

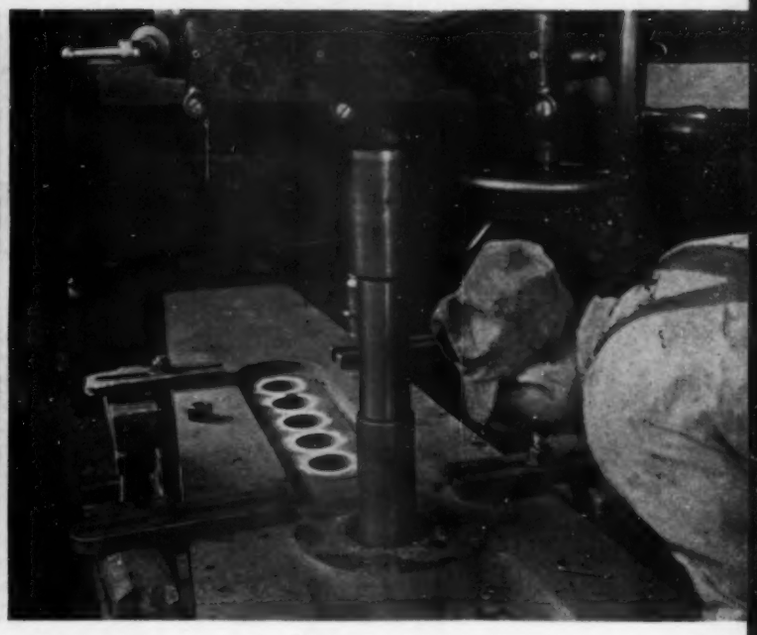


In the main machine bay at the Lufkin Foundry & Machine Company heavy machines are located to the right of a center aisle while much of the space to the left is devoted to assembly operations, except at the rear of the bay. A traveling crane over the bay and jib cranes at frequent intervals provide material-handling facilities. The manufacture of gears and gear casings, seen in the foreground, typifies the work done in this shop



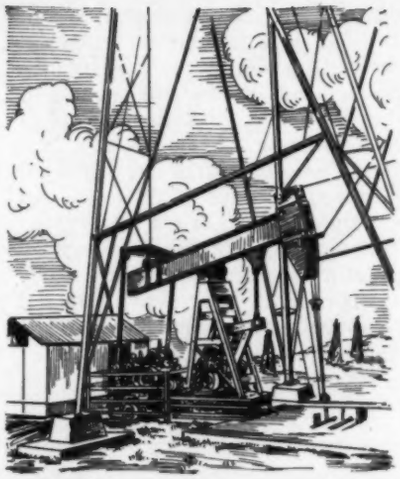
Single- and double-reduction gear units, used in oil-pumping machinery, are assembled at one end of the machine bay. The traveling crane and one jib crane are used for assembling these units. At the upper right, several pumping units are seen loaded on a flat car ready for shipment





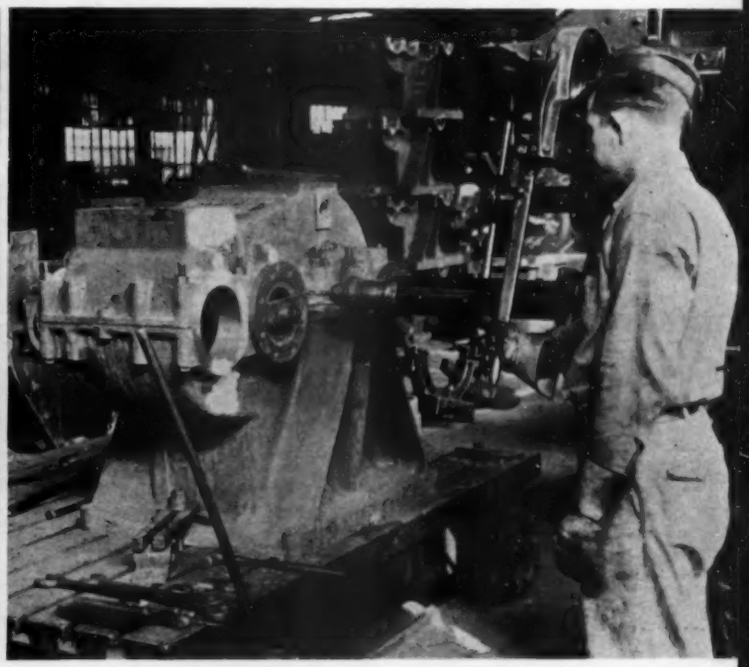
Three gear-case sections are machined simultaneously on a Niles boring mill. Shaft and bearing fits are bored on a Lucas horizontal mill with the aid of fixtures to assure perfect alignment, permitting standardization and interchanging of casing sections

Heavy steel connecting rods or arms for pumping machinery are finished on a Rockford hydraulic planer. This machine, with its fast cutting speeds, rapid traverse heads, and fast-return bed has decreased production time materially on these arms, two of which are machined at the same time



After the arms or connecting rods for pumping units have been planed, the main or shaft hole and the crank pin or throw holes are bored on a Bickford radial drill press. The holes are laid out by the usual chalk and scriber method, the boring tools being located by the scribed lines

Jig drilling of flange studs in gear casings is done on a horizontal floor machine. The work is located on a truck the axles of which have castellated wheels for moving the truck and work horizontally; the machine spindle provides vertical movement.



IDEAS FROM PRACTICAL MEN

Progressive Press Tools

By H. B. FAUGHT

The four station progressive press tools illustrated are for producing the part *A* from S.A.E. 1010 soft drawing steel. The sequence of operations is indicated by numerals in both the plan view of the die and in the view of the stock strip. After the first three strokes of the ram a piece is finished at each succeeding stroke. At station 1 in the stock strip *B* will be seen how the blank is held by two narrow wings until it reaches the final station. The notched portion indicated by dash-dot lines shows where the stock is cut away by the notching punch *C* in the three strokes necessary to produce the first finished piece.

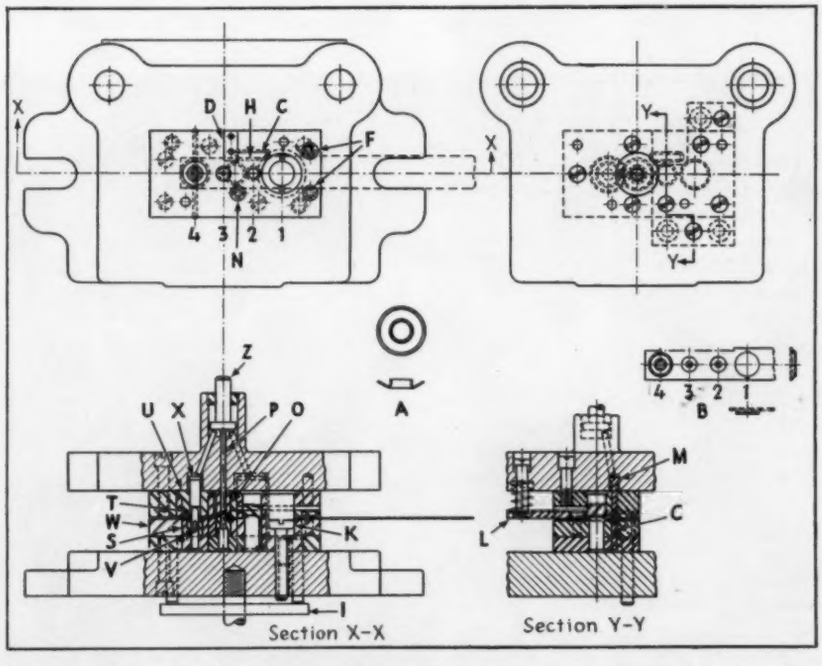
Referring to the plan view of the die it will be seen that the only stop is the stop block *D*, which also serves as a stock guide and a stripper after the first operation.

In operation, the stock is placed under the heads of pins *F* and is advanced against stop block *D*. On the first descent of the ram, a shearing operation is performed at station 1, and at station 2 drawing and notching are done. By virtue of the die bushing at station 1 being notched on two opposite sides and the face of the punch being flat, the blank is sheared part way around only, leaving two narrow wings so that it will not be distorted at station 3 after the drawing operation at station 2 which has just been performed.

At *H* the stock is notched or cut away a distance equal to the center distance between the blanks. It will be noted here that the corner of the notched portion of the stock is in a position just ahead of the opening in the shearing die a distance equal to the thickness of the stock. That allows for the width of metal between blanks and also provides for a scrap margin at the end of the strip for the first blank. When the ram ascends, pressure plate *I* is forced upward by a rubber buffer (not shown) until it is stopped against the bottom of the die shoe, at which time the sheared portion of the blank will have been pushed back into the opening in the stock by the shedder *K*. Stripper plate *L* holds the stock down firmly on the die block while the sheared portions are being pushed back into the openings from which they came. As the ram continues its ascent, the spring stripper strips the stock from the punch and the slug from the notching operation is ejected by knockout *M*.

On the next advance of the stock, the portion that has been notched passes between block *D* and pin *N* until its corner stops against block *D*. When the ram descends, a repetition of the first three operations occurs, and at station 3 a $\frac{3}{16}$-in. hole is pierced, the slug being ejected from bushing *O* by the knockout pin *P*. The notched portion of the stock is advanced against block *D* as before and the blank is now at station 4. On the next descent of the ram, the blank is cut from the strip by the blanking and forming die bushing *S*, and is forced down over the sizing punch *T* until it has been finish formed between bushings *S* and *U*. On the upstroke of the ram, the inner bushing *V*, which is slidable in bushing *S* and is secured to pressure pad *W* by pins, is carried upward with the pad, stripping the finished part from the sizing punch. The finished part is ejected from bushing *U* by the knockout pin *X* and is blown from the die by an air jet.

The sizing punch has an elongated hole of sufficient length to allow for travel of the pressure pad. The knockouts *M*, *P* and *X* are actuated by the plunger *Z* through contact with the press knockout bar.

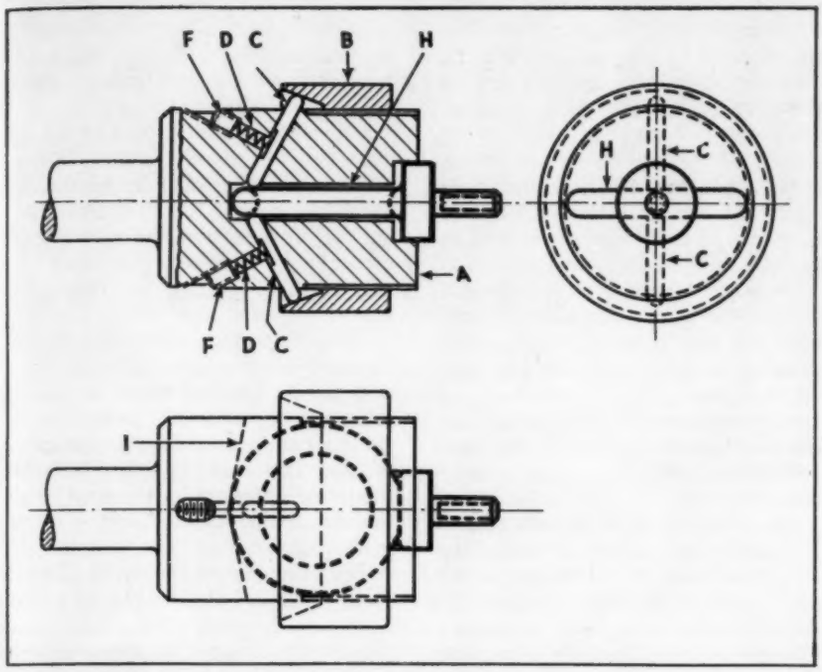


Three operations, shearing, notching and drawing, are performed at the first down stroke of the ram. The only stop necessary is a stationary block

Auxiliary Chuck for Holding Eyebolts

By W. M. HALLIDAY
Peterborough, Northants, England

Often the common type of eyebolts have to be remachined to extend the thread farther up the shank, to rechase the thread to make it smaller in diameter, or to reface the shoulder so that the eye will stand in a determined position when the bolt is screwed up to the shoulder. To hold the eyebolts



In remachining eye bolts it is necessary to provide some special means for holding them, since they cannot be held in an ordinary lathe chuck

for any or all of these operations, the auxiliary chuck illustrated has been designed.

Essentially the chuck consists of the body *A* having a straight shank for holding it in an ordinary lathe chuck; the internally threaded ring *B*, which is knurled on the outside for a finger grip; the plungers *C*; the springs *D*; and the screws *F* for retaining the springs. The body is mild steel and the front portion is threaded for the threaded ring. A slot is cut at *H* to receive the eye of the bolt; the bottom of the slot forms a shallow Vee, as shown by the dotted line *I*, the apex of the Vee being accurately in the center line of the body. The front of the body is bored to receive the shoulder of the bolt, being slightly smaller at its inner end so as to fit the shoulder tightly and insure its being centered. A portion of the threaded ring is bored conically to actuate the plungers, which have a sliding fit in angularly disposed holes passing into the inner end of the slot. The springs are inserted in holes drilled at right angles to the plunger holes and are retained by small screws. The springs bear on flats filed in the plungers to prevent them from falling out when the chuck is empty. Both the threaded ring and the ends of the plungers are hardened and highly polished to minimize friction.

In operation, the threaded ring is unscrewed so that its conical bore is out of contact with the outer ends of the plungers and an eyebolt is put in the chuck. The threaded ring is then screwed up so that its conical bore contacts the outer ends of the plungers and forces them inward. Continued screwing up the ring exerts pressure on the plungers and causes their inner ends to grip the metal around the eye of the bolt and hold it firmly in the shallow Vee at the bottom of the slot.

Grinding Thin Washers

By C. G. WILLIAMS

The method described by J. G. Miller (*AM*—Vol. 83, page 306) for grinding thin washers may work in some cases, but I would not consider it for washers under 0.010 in. in thickness because the skin tension set up by the shellac in drying will cause distortion strains that may be as hard to correct as are those set up by the direct pull of the magnetic chuck. If the washers were set directly on the steel, that effect would be intensified by the pull of the magnetic chuck, for it may be that even so light a pull will set up some strains. Also it may be that displacement of the shellac by the pull will assist in its efforts to distort the washer. Again, the slight heat caused by grinding may cause the shellac to swell in the thicker portions and add to the distortion.

My method, which has succeeded in producing flat washers from 0.002 to 0.008 in. in thickness, is to attach a thin washer of leather to the steel plate with either glue or shellac. After drying, the assembly is placed on the magnetic chuck and a very light cut is taken off the top of the leather. The leather is then given a light coat of glue or shellac and after drying it is touched up on the grinder, permitting the wheel to just touch the surface at all points. A very thin coat of adhesive is then flowed over the surface and the washer to be ground is dropped on it. The washer is not allowed to drop so as to touch one side of the adhesive first, but is held as nearly parallel with and as close to the surface as is possible before it is allowed to drop the $\frac{1}{32}$ in. more or less that it may fall. If one side of the washer is allowed to touch the adhesive before the other, it will cause a slight flow of the adhesive to the high side and may cause another distortion.

Washers have been held to one micron difference in thickness in 2 in. by this method.

Cutting Multiple Threads

By ELMER OLSON

There are many old lathes that do not have micrometer collars on either the crossfeed or compound-rest screws, so it would not be possible to use them for cutting multiple threads by the method described by Mr. Olson (*AM*—Vol. 83, page 346). However, it is possible to "split" some threads by engaging the half-nut on the lead screw when the thread indicator on the apron is in certain positions, although it depends upon the ratio of the pitch of the lead screw to that of the screw to be cut. When I was an apprentice I used to watch my neighboring lathe hand cutting triple-thread screws having a lead of $3\frac{3}{4}$ in. and a pitch of $1\frac{1}{4}$ threads per in. He "split" the threads by engaging the half-nut on the lead screw when the lines on the thread indicator were in a certain position as shown by the pointer, feeding in the tool by the compound rest for each thread.

In cutting double-thread screws I have often found it convenient to turn the gear on the lead screw a half revolution for cutting the second thread, first marking the meshing points of both gears with chalk.

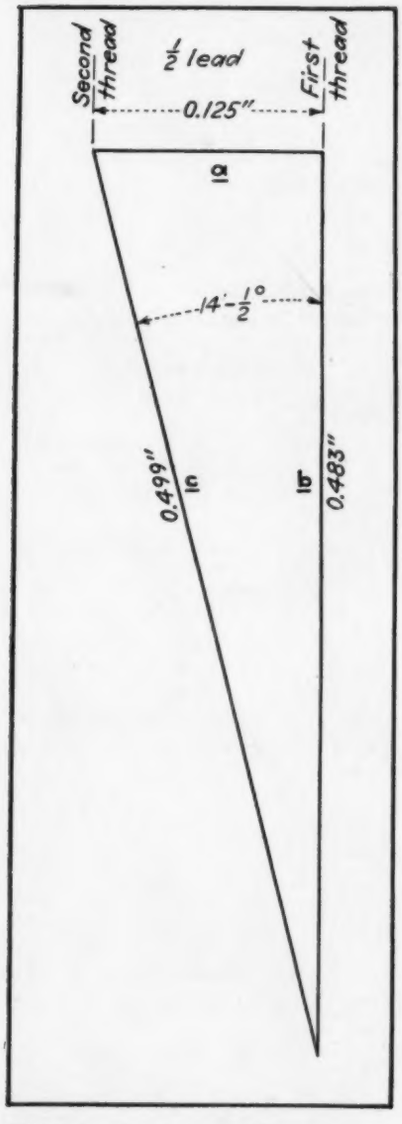
When tools for cutting square threads have become too thin, either from wear or repeated regrinding, the threads can be cut to the correct width

without resetting the tool by shifting the meshing teeth on the lead screw a tooth or two in the intermediate gear.

By W. B. DASHIELL

Shop Foreman,
Holly Sugar Corporation

While Mr. Olson gave a very good idea of how to cut the second thread in multiple threading, he did not tell how his figures were arrived at; therefore, I would like to add to the value of his article by giving the data, using his drawing for that purpose; Mr. Olson's drawing is reproduced above.



This triangle represents the movement of the tool by toolblock and compound rest in cutting a double thread Acme screw of 0.250-in. lead

Let a = one-half the lead of the thread to be cut; b = the distance to draw back the toolblock on the cross-slide; and c = the distance to feed in the tool by the compound rest. Then b/a = cot 14½ deg. = 3.86671; therefore, $b = a \times$ cot 14½ deg. = $0.125 \times 3.86671 = 0.483$ which is the distance to draw back the toolblock on the cross-slide. Also a/c = sin 14½ deg. = 0.25038; therefore, $a = c \times$ sin 14½ deg., and $c = a/$sin 14½ deg. = $0.125/0.25038 = 0.499$ which is the distance to feed in the tool by the compound rest.

In other words, with a two-start thread of 14½ deg. flank angle, one-half the lead times 3.86671 is the distance to draw back the toolblock on the cross-slide, and one-half the lead divided by 0.25038 is the distance to feed in the tool by the compound rest for starting the second thread.

In cutting multiple threads of any lead and any number of starts, the compound rest should be set to the flank angle of the thread and the dimension a should be equal to the lead divided by the number of starts. Then, modifying the equations given by the varying values of a, they can be applied as in the case cited.

Draftsmen's Convertible Reference Table

By A. DUNTON

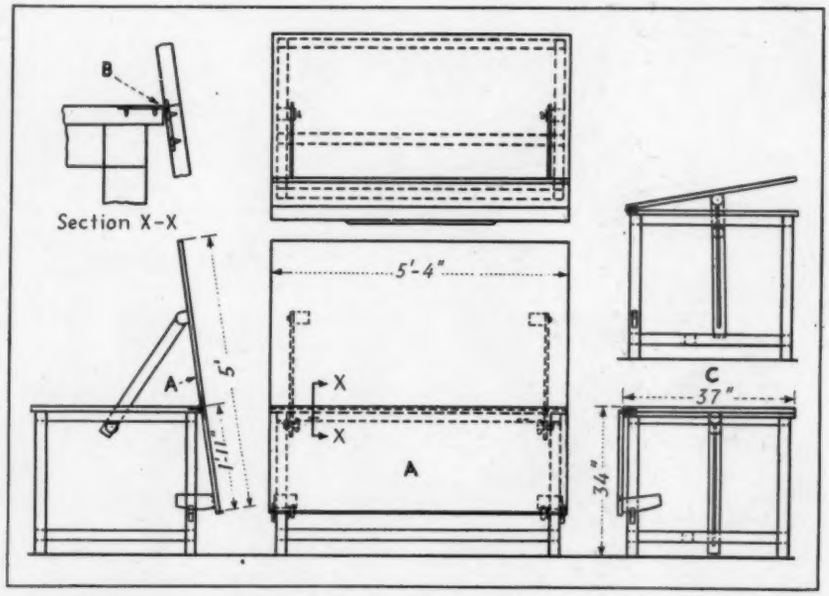
Lachine, Quebec, Canada

The convertible horizontal and vertical reference and drafting table illustrated has been developed to eliminate unnecessary motions of the draftsman and thereby increase his output. It has been found that for reference purposes, an inclined table top sloping about 10 deg. backward saves effort. For the greatest convenience to the draftsman, the inclined reference table should be placed at an angle of 45 deg. in plan, facing toward the draftsman at his work. With that layout the draftsman can get his information from the reference print by merely turning 45 deg. without getting up from his seat.

Other important advantages of the convertible table are that wide layouts can be handled which it would otherwise be impossible to reach, and the floor space taken up by the table is not increased by the inclined mounting of prints, as it would be if the extra-wide prints had to have extra-wide tables.

With the design shown, the lower front portion *A* of the table can easily be removed, owing to the half-bearings *B* of the hinges, as shown in section *X-X*. The table is then suitable for use as an ordinary drafting table, as shown at *C*. If desired, the table can be easily converted into the usual horizontal reference table, as shown in the lower right-hand corner of the drawing.

It sometimes happens that there is a shortage of reference-table space in the drafting room. In that case the front of the table can be used in the inclined position while the horizontal surface is also available so that the total area is more than doubled without any extra equipment or floor space being needed.



The reference table can be used either horizontally or nearly vertically, or in a combination of both. By removing the front leaf it becomes a drafting table

The Working of WROUGHT BRONZES

BRONZE is a term applied in recent years to a wide range of copper alloys. Some of these alloys contain both tin and zinc, others contain neither. As a name, *bronze* was used for centuries to designate binary copper-tin alloys while the term brass was given to alloys of copper and zinc.

In late years the word bronze has lost its significance as a designation for a given group of alloys. In fact the term has been so modified by common usage that the S.A.E. Handbook, in differentiating between brass and bronze, reads: "Brass is an alloy of copper and zinc, while bronze is usually an alloy with a typical bronze color." It now is common practice to qualify the term bronze with an adjective descriptive of the particular alloy—we have, for instance, manganese, tin, silicon and aluminum bronzes.

From a broad viewpoint, bronzes may be divided into three general classifications: (1) Phosphor bronzes, which are copper-tin alloys containing small amounts of phosphorous as a deoxidizing agent; (2) Special bronzes, including the aluminum and silicon bronzes, which contain substantial proportions of an alloying metal other than tin; and (3) Improved copper-zinc alloys containing small amounts of tin and/or other modifying elements.

Much of the available data concerning the characteristics, applications and common methods of fabricating the various wrought bronzes and other alloys of copper, not including the brasses, has been summarized on the following pages. No attempt has been made to list all of the alloys available, those selected being typical mill alloys which have wide application and usually must be worked or machined in one manner or another before being finally put to use. The working of wrought coppers and brasses, or copper-zinc alloys was discussed in a previously published section on these materials, (*AM*—Vol. 82, page 1101).

Part of the data used in preparing this discussion has appeared in the Metals Handbook, 1939 edition, published by the American Society for Metals; in specifications published by the American Society for Testing Materials and by the Society of Automotive Engineers; in bulletins published by the Copper and Brass Research Association of New York and the Copper Development Association of London; and in literature made available by the companies that have cooperated in the preparation of this material. Reference sources also consulted include Marks' Mechanical Engineers' Handbook and American Machinists' Handbook published by the McGraw-Hill Book Company; also Kents' Mechanical Engineers' Handbook and Eshbach's Handbook of Engineering Fundamentals published by John Wiley and Sons.

Like coppers and brasses, the physical properties and working characteristics of the various so-called *bronze* alloys depend greatly upon such highly variable mechanical factors as size, shape and temper. To tabulate the properties and characteristics of all of these alloys under all combinations of conditions would be impractical. For this reason any discussion of these properties must be in general terms and approximate values. Often it is difficult to predict, without actual trial, whether an alloy will be suitable for a given application, or can be worked by a given process.

In the text and tables references are made to the relative suitability of the various alloys for different fabricating operations; also a relative machinability rating is listed for most of the alloys. These ratings can be considered as first approximations only, and serve to indicate in a broad sense the suitability of the alloy for a given application. For a discussion of the standard forms, tempers and finishes in which these alloys are available, and of the tempers in which they are supplied, reference should be made to the previous discussion of the working of wrought coppers and brasses.

Selection of the proper alloy for a given service application requires

The editors of American Machinist *express their sincere appreciation to the following companies for assistance in the preparation of this section:*

Abrasive Company
American Brass Company
American Swiss File & Tool Company
Beryllium Copper Corp. of Pa.
Bridgeport Brass Company
Brown & Sharpe Mfg. Company
Carboloy Company, Inc.
Chase Brass and Copper Company
Cleveland Twist Drill Company
A. P. deSanno & Son, Inc.
Henry Disston & Sons, Inc.
Firth-Sterling Steel Company
Greenfield Tap and Die Corporation
Hanson-Van Winkle-Munning Company
Illinois Tool Works Company
Landis Machine Company
Linde Air Products Company
Morse Twist Drill & Machine Company
National Twist Drill & Tool Company
Norton Company
Phelps Dodge Copper Products Corp.
Revere Copper and Brass Incorporated
Riverside Metal Company
Scovill Manufacturing Company
Standard Oil Company of Indiana
D. A. Stuart Oil Company
Texas Company
Tide Water Associated Oil Company
Wells Manufacturing Corporation
Westinghouse Electric & Mfg. Company

more than a mere reference to a handbook and a check on the physical properties. A number of questions must be answered. How will the metal stand up in service under the given set of conditions; will it be liable to failure because of corrosion or fatigue? How does it compare in price and fabricating cost with other materials that might be substituted? Is it practical from a manufacturing standpoint? Can it be cold worked, hot forged, machined, welded, soldered, riveted, buffed, plated?

TIN BRONZES

The tin bronzes, frequently referred to as *phosphor bronzes* because of the general practice of using phosphorous as a deoxidizing agent, are, as a class, characterized by high strength, good ductility, great resilience and high corrosion resistance. They have high resistance to fatigue, low coefficient of friction, and high resistance to wear. The alloys containing from 4 to 10 per cent tin have good spring properties.

Alloys containing up to about 2 per cent tin, with little or no phosphorous, can be hot worked readily. Those containing less than about 4 per cent tin with low phosphorous can be hot worked to a lesser extent. Good cold workability is shown by all alloys in this group; however, the hardness and power required for cold working increases with increasing tin content. Some leaded phosphor bronzes are suitable for screw machine work, but the improvement in machining qualities is obtained at the expense of ductility and malleability.

"Carobronze," an alloy which has had wide use in bearing applications in Europe and now is being introduced in the United States, is in composition a phosphor bronze with a higher than usual phosphorous content. The good bearing qualities, resistance to shock and vibration, high load carrying ability and high strength claimed for this alloy are developed by the extensive cold working carried on during the fabrication process. The metal produced is very dense; it machines somewhat like mild steel with a curling chip.

NICKEL SILVER

The name *nickel silver* has been generally applied to copper-nickel-zinc alloys of various proportions. They may more properly be termed nickel brasses. Some of these alloys contain small percentages of lead to improve machinability. They find wide application because of their color, corrosion resistance, high strength and ductility, and ease of working. The 12 per cent leaded alloy is widely used for keys and cylinder locks. In addition to white alloys, subdued pink, green and yellow tints can be secured by suitable adjustment of the copper-nickel-zinc ratios.

In general, the nickel silvers are highly malleable and ductile. Many can be drawn, stamped, formed, spun, upset, forged, extruded, machined, threaded, welded and cast. They have a higher resistance to general corrosion than brass containing like amounts of copper; this corrosion resistance is improved as the percentage of nickel is increased. If the material is to be used for purposes requiring high resistance to corrosion or to fatigue, or if there is to be considerable fabricating, such as deep drawing, bending or double seaming, an 18 per cent nickel silver alloy having a high copper-to-zinc ratio usually is considered best. A higher zinc content will reduce the ductility and general workability of the alloys, but permits the development of spring properties.

Straight mixtures of copper and nickel, known as cupro-nickels, are notably resistant to general chemical, impingement and erosion types of corrosion. They have good strength and ductility characteristics. The alloys containing 15, 20 and 30 per cent nickel are the most common, although some have a nickel content as low as 2.5 per cent.

The 15 and 20 per cent nickel alloys in this group can be cold worked to a considerable degree without intermediate annealing. The 30 per cent cupro-nickel alloy can be cold worked only slightly less than the other two, and all are readily hot forged. They can be soft soldered, silver soldered, brazed and welded. The 20 per cent cupro-nickel alloy has been used successfully for turbine blades.

MANGANESE BRONZE

Basically a "high tensile brass," the copper-zinc alloy known as *manganese bronze* contains small amounts of manganese, iron and tin which improve its mechanical properties and corrosion resistance. The addition of tin improves corrosion resistance and also hardens and strengthens the alloy. Iron reduces grain size for a given annealing treatment. Manganese refines the grain structure, increases strength and improves the working characteristics.

This alloy is readily hot worked, but has poor cold working properties. It is readily welded by the oxy-acetylene torch and, with zinc-free copper alloy rods such as some of the phosphor bronzes and copper-silicon alloys, carbon arc welds of moderate strength can be obtained.

ALUMINUM BRONZE

The aluminum bronzes are corrosion-resistant alloys of high strength, with a hardness equivalent to that of manganese bronze. They have good anti-frictional properties. The wrought forms generally contain from 4 to 10.5 per cent of aluminum, with or without other metals. Mechanical properties usually are high and may be varied over a wide range by adjusting the composition, the amount of working and by heat-treatment.

In general, these alloys are characterized by excellent resistance to the corrosive attack of acid solutions. They combine the strength and ductility of medium carbon steel and may be readily forged, and hot or cold rolled. Good bearing qualities, hardness and resistance to shock and

CHEMICAL COMPOSITION OF A.S.T.M. PHOSPHOR BRONZES

Components	Grade A	Grade B	Grade C	Grade D
Tin, per cent	3.80–5.80	4.00–5.50	7.0–9.0	9.0–11.0
Phosphorus, per cent	0.03–0.35	0.03–0.25	0.03–0.25	0.03–0.25
Iron, max., per cent	0.10	0.10	0.10	0.10
Lead, max., per cent	0.05	2.50–4.00	0.02	0.02
Antimony, max., per cent	0.01	....	0.01	0.01
Zinc, max., per cent	0.30	0.20	0.20	0.20
Nickel, max., per cent	....	....	0.15	....
Copper, per cent	remainder	remainder	remainder	remainder
Copper plus tin plus phosphorus, min., per cent	99.50	99.50	99.50	99.60

A.S.T.M. tentative specification No. B103-39T covering sheet and strip phosphor bronze commonly used for drawing, forming, stamping and bending, lists four standard grades

fatigue are among the properties that have led to the selection of these alloys for such applications as gears, diaphragms, valve stems, and slide liners. Sheet and strip stock can be formed by drawing and spinning.

BERYLLIUM COPPER

The important characteristics of beryllium copper alloys, which were introduced in the United States in 1931, are high strength and hardness, high fatigue resistance, high wear resistance, and the corrosion resistance of copper. The physical properties may be increased by heat-treatment. Articles may be formed when the metal is soft and they can then be heat-treated to strengths and hardnesses beyond those of the hardest bronzes. The improvement in physical properties (up to 200,000 lb. per sq. in. tensile strength and 360 Brinell) is caused by "precipitation" of the *gamma* phase from the super-saturated solid solution.

Most of the wrought beryllium copper available at present contains 2 to 2.25 per cent beryllium and up to 0.25 per cent iron. One producer adds up to 0.50 per cent nickel to refine the grain and increase ductility. Beryllium copper may be cold worked by any of the processes applicable to phosphor bronze in similar forms. It work hardens rapidly and frequent anneals are necessary.

Hot working is possible but not so easy as with aluminum bronze or the copper-silicon alloys. The alloy can be soft soldered, silver soldered, or welded with the carbon arc. It can be plated by usual methods. Whether hardened by cold working, heat-treatment or both, it can be softened by heating to 1,427-1,472 F. and quenching rapidly in cold water. It may be rehardened by cold working or by reheating to 482-617 F.

Beryllium copper formed into various shapes by cold working does not need a solution heat-treatment before hardening. Articles which have been hot worked, welded or hard soldered must be heated to 1,427-1,472 F. for two to three hours and then quenched in water before they will respond satisfactorily to the precipitation hardening treatment. This treatment is accomplished at a carefully controlled temperature in a muffle furnace, salt bath, or oil bath.

COPPER-SILICON ALLOYS

The silicon bronzes, more properly termed *copper-silicon alloys,* constitute a very useful group. They combine high strength, and other properties comparable with those of mild steel, with the corrosion-resistance of copper. They are non-magnetic, hot work readily, and can be welded by any of the standard commercial methods of gas or electric welding. They can be cold-worked, and when work hardened can be heat-treated to relieve internal stresses without sacrifice of strength or hardness. These alloys can be spun, stamped, drawn and forged, and are available in all standard forms. They may contain from 1.5 to 4 per cent silicon; lesser amounts of manganese, zinc, lead or tin; and the balance copper. Representative trade names are: Everdur, American Brass Company; Duronze, Bridgeport Brass Company; Olympic Bronze, Chase Brass & Copper Company; P-M-G, Phelps Dodge Copper Products Corporation; Herculoy, Revere Copper and Brass Incorporated; and Arcoloy, American Radiator Company. The last named alloy is made up of about 97.24 per cent copper, 2.63 silicon, 0.12 per cent iron, and 0.01 per cent phosphorous.

OTHER COPPER ALLOYS

Various combinations of differing alloying elements make possible the diverse physical characteristics and working properties of the various so-called bronzes available on the market. Alloys not included in the accompanying tabulations include a number, like the cadmium, chromium and other bronzes, that have specialized applications such as trolley wires, long-span electric transmission wires, special condenser tube alloys, and the like. A number of these alloys might well be, and in a few instances are, used for other purposes. Generally, however, there may be found other alloys better suited to, or more economical for, such uses.

Good machinability in copper-base alloys has been obtained, for the most part, by the incorporation of lead in these alloys. Within recent years, however, workers in these metals have reported interesting improvements in machinability made possible through additions of selenium or tellurium instead of lead. An alloy containing 97.8 per cent copper, 1.5 per cent tin and 0.95 per cent tellurium was reported by H. L. Burghoff and D. E. Lawson (Transactions of the American Institute of Mining and Metallurgical Engineers, 1938) to have a relative machinability of 135 per cent in the annealed condition and 142 per cent when drawn to a reduction of 36 per cent (machinability of free-cutting brass taken as 100 per cent). The report indicates that the addition of tellurium has no appreciable effect on the tensile strength of the alloy. Selenium and tellurium have practically no solid solubility.

COPPER-NICKEL-ZINC AND COPPER-NICKEL ALLOYS

Alloy	Copper Per Cent	Nickel Per Cent	Zinc Per Cent	Tensile Strength Lb. per Sq. In. (Hard)
No. 1	72	18	10	73,000–84,000
No. 2	65	18	17	79,000–91,000
No. 3	66	10	24	79,000–96,000
No. 4	55	18	27	92,000–106,500
No. 5	70	30	..	71,000–82,000
No. 6	80	20	..	72,000–76,500
No. 7	75	20	5	79,000–85,000

Seven standard copper-nickel-zinc and copper-nickel alloys, for which the above are nominal compositions, are listed in A.S.T.M. tentative specification No. B122-39T. These alloys are used for many purposes

CORROSION RESISTANCE

The conditions influencing the corrosion resistance of a metal are complex. It is practically impossible to give definite information regarding the anti-corrosion properties of any alloy without consideration of the character, concentration, temperatures and velocity of corroding agent or agents to which the metal will be subjected. Generally, certain copper-base alloys resist corrosion better than others; there are no hard and fast rules, however, and in almost every case a trial under service conditions must be made before a new alloy can be recommended for a given application. Often the joint use of dissimilar alloys is the source of much corrosion trouble, in other cases the problem of "season cracking" can be solved only by substituting an alloy having a higher corrosion resistance nder the given set of conditions. Each case must be considered separately.

PHYSICAL & FABRICATION CHARACTERISTICS OF

TYPICAL WROUGHT BRONZES and OTHER COPPER ALLOYS Not including the Wrought Coppers and Copper-Zinc Alloys (Brasses) previously discussed (*A. M.*— Vol. 82, page 1101). Commonly Used Trade Names	APPROXIMATE CHEMICAL COMPOSITION (Per Cent)												APPROXIMATE TENSILE STRENGTH (1,000 lb. per sq. in.)				APPROXIMATE YIELD POINT (‡) (1,000 lb. per sq. in.)			
													Commercial Sheet Stock — Approx. 0.040-in. Thick		Commercial Rod Stock — Approx. 1-in. Dia.		Commercial Sheet Stock — Approx. 0.040-in. Thick		Commercial Rod Stock — Approx. 1-in. Dia.	
	Copper	Tin	Phosphorous	Lead	Manganese	Silicon	Nickel	Zinc	Iron	Aluminum	Beryllium	Arsenic								
	Cu	Sn	P	Pb	Mn	Si	Ni	Zn	Fe	Al	Be	As	Hard (*)	Soft	Hard (*)	Soft	Hard (*)	Soft	Hard (*)	Soft
Tin or Phosphor Bronzes																				
Phosphor Bronze	98.75	1.25	Tr.	....	....	....	....	....	....	....	....	....	65	40	....	...	....	...	....	...
4% Phosphor Bronze (Grade A)	95.75	4.0	0.25	....	....	....	....	....	....	....	....	....	82	50	....	...	....	18	....	...
5% Phosphor Bronze (Grade A)	94.9	5.0	0.10	....	....	....	....	....	....	....	....	....	82	50	70	...	60	20	55	...
8% Phosphor Bronze (Grade C)	91.9	8.0	0.10	....	....	....	....	....	....	....	....	....	92	60	....	...	65	25	....	...
10% Phosphor Bronze (Grade D)	89.4	10.5	0.10	....	....	....	....	....	....	....	....	....	102	65	....	...	70	28	....	...
Leaded Phosphor Bronze (Grade B)	93.9	5.0	0.10	1.0	....	....	....	....	....	....	....	....	82	50	70	...	60	20	55	...
Free-Cutting Phosphor (Bushing) Bronze	87.55	4.0	0.45	4.0	....	....	....	4.0	....	....	....	....	....	...	60	...	....	...	45	...
"Carobronze" Bearing Alloy	91.2	8.5	0.30	....	....	....	....	....	....	....	....	....	90	63	100	65	....	...	....	...
Nickel Silvers																				
10% Nickel Silver	65.0	.....	....	....	....	....	10.0	25.0	....	....	....	....	86	55	....	...	70	20	....	...
15% Nickel Silver (64% Copper)	64.0	.....	....	....	....	....	15.0	21.0	....	....	....	....	85	55	....	...	....	...	....	...
15% Nickel Silver (57% Copper)	57.0	.....	....	....	....	....	15.0	28.0	....	....	....	....	90	55	....	...	....	...	....	...
18% Nickel Silver (65% Copper)	65.0	.....	....	....	....	....	18.0	17.0	....	....	....	....	86	58	....	...	65	...	....	...
18% Nickel Silver (55% Copper)	55.0	.....	....	....	....	....	18.0	27.0	....	....	....	....	100	60	....	...	....	...	....	...
20% Nickel Silver	75.0	.....	....	....	....	....	20.0	5.0	....	....	....	....	75	50	70	50	55	20	50	18
12% Leaded Nickel Silver	65.0	.....	....	1.0	....	....	12.0	22.0	....	....	....	....	85	58	....	...	....	...	....	...
12.5% Leaded Nickel Silver	61.0	.....	....	1.5	....	....	12.5	25.0	....	....	....	....	90	...	....	...	....	...	....	...
18% Leaded Nickel Silver	63.25	.....	....	1.0	....	....	18.0	17.75	....	....	....	....	....	...	75	...	....	...	....	...
10% Extruded Nickel Silver	46.5	.....	....	2.75	....	....	10.0	40.75	....	....	....	....	....	...	....	...	....	...	....	...
13% Extruded Nickel Silver	42.25	.....	....	0.5	2.0	....	13.0	42.25	....	....	....	....	....	...	....	...	....	...	....	...
13% Extruded Nickel Silver	43.25	.....	....	....	....	....	13.0	43.75	....	....	....	....	....	...	....	...	....	...	....	...
Cupro — Nickels																				
15% Cupro — Nickel	85.0	.....	....	....	....	....	15.0	....	....	....	....	....	67	45	....	...	50	...	....	...
20% Cupro — Nickel	80.0	.....	....	....	....	....	20.0	....	....	....	....	....	70	48	....	...	....	...	....	...
30% Cupro — Nickel	70.0	.....	....	....	....	....	30.0	....	....	....	....	....	72	50	70	50	60	20	55	20
Copper — Nickel — Tin (Adnic)	70.0	1.00	....	....	....	....	29.0	....	....	....	....	....	130	55	95	55	....	25	....	25
Aluminum Bronzes																				
5% Aluminum Bronze	95.0	.....	....	....	....	....	....	....	....	5.0	....	....	90	52	75	52	....	...	....	...
8% Aluminum Bronze	92.0	.....	....	....	....	....	....	....	....	8.0	....	....	100	60	90	60	65	...	60	...
Nickel — Aluminum Bronze	89.5	.....	....	....	....	....	0.5	.....	0.5	9.5	....	....	....	...	88	...	....	...	43	...
5% Nickel — Aluminum Bronze	81.9	.....	....	....	1.0	....	5.0	....	2.5	9.6	....	....	....	...	105	...	....	...	60	...
Nickel — Aluminum Bronze (Type A)	92.0	.....	....	....	....	....	4.0	....	....	4.0	....	....	90	50	....	...	....	...	....	...
Nickel — Aluminum Bronze (Type B)	91.0	.....	....	....	....	....	7.5	....	....	1.5	....	....	....	...	115	50	....	...	....	...
Copper — Silicon Alloys																				
Everdur No. 1010	95.8	.....	....	....	1.1	3.1	....	....	....	....	....	....	95	55	95	55	65	20	65	20
Everdur No. 1012	95.6	.....	....	0.40	1.0	3.0	....	....	....	....	....	....	....	...	95	...	....	...	65	...
Everdur No. 1015	98.25	.....	....	....	0.25	1.5	....	....	....	....	....	....	65	40	70	40	50	10	55	10
Duronze I	97.5	1.50	....	....	....	1.0	....	....	....	....	....	....	65	40	70	40	....	...	....	...
Duronze II	97.0	.....	....	....	....	3.0	....	....	....	....	....	....	92	55	85	55	60	15	50	15
Duronze III (Silicon — Aluminum Bronze)	91.0	.....	....	....	....	2.0	....	....	....	7.0	....	....	....	...	95	80	....	...	....	...
Olympic Bronze — Type A	96.0	.....	....	....	....	3.0	....	1.0	....	....	....	....	93	56	93	...	....	...	....	...
Olympic Bronze — Type D	95.5	.....	....	0.50	....	3.0	....	1.0	....	....	....	....	....	...	93	...	....	...	....	...
Olympic Bronze — Type G (Silicon Brass)	77.0	.....	....	....	....	1.0	....	22.0	....	....	....	....	96	63	....	...	....	...	....	...
Herculoy No. 418	96.25	0.50	....	....	....	3.25	....	....	....	....	....	....	110	60	125	60	100	24	120	24
Herculoy No. 419	97.75	0.25	....	....	....	2.0	....	....	....	....	....	....	100	45	110	45	95	22	97	22
Herculoy No. 420	96.0	.....	....	....	1.0	3.0	....	....	....	....	....	....	110	60	125	60	100	24	120	24
Herculoy No. 421	98.0	.....	....	....	0.25	1.75	....	....	....	....	....	....	100	45	110	45	95	22	97	22
P-M-G No. 3	98.2	.....	....	....	....	1.20	....	.....	0.60	....	....	....	75	40	75	40	40	15	40	15
P-M-G No. 10	95.6	.....	....	....	....	3.20	....	.....	1.20	....	....	....	95	60	110	60	60	24	65	30
P-M-G No. 95	96.6	.....	....	0.40	....	2.50	....	.....	0.50	....	....	....	....	...	90	55	....	...	55	25
P-M-G No. 96	97.0	.....	....	....	....	2.50	....	.....	0.50	....	....	....	90	55	90	55	55	20	55	20
Other Alloys																				
Arsenical Bronze	56.5	.....	....	0.70	....	....	2.0	39.0	1.20	....	....	0.60	....	...	87	65	....	...	....	...
Beryllium Copper	97.4	.....	....	....	....	....	0.35	.....	Tr.	....	2.25	....	118	70	....	...	90	30	....	...
Beryllium Copper (Precipitation Hardened)	97.4	.....	....	....	....	....	0.35	.....	Tr.	....	2.25	....	190	175	....	...	97	95	....	...
Manganese Bronze	59.0	0.70	....	....	0.50	....	....	39.0	0.80	....	....	....	90	60	85	60	....	25	60	25

Note: All of the values shown are subject to manufacturing limitations. These data should not be used in the preparation of specifications. — Note (*): For some alloys the values given are for a temper slightly different from that commonly known as hard (Rolled about 4 B. & S. gage numbers hard for sheet stock) — Note (‡): Yield strength taken as the load producing an extension under stress of 0.50 per cent.

TYPICAL WROUGHT BRONZES & OTHER COPPER ALLOYS

APPROXIMATE ELONGATION (Per Cent in 2-in.)				ROCKWELL HARDNESS NUMBER				Young's Modulus of Elasticity (Lb. per Sq. In.) Hard (*) (× 10⁶)	Average Linear (†) Coefficient of Expansion (× 10⁻⁶)	Density (Lb. per Cu. In.)	Melting Point (Degrees Fahrenheit)	Electrical Conductivity (Per Cent I. A. C. S. at 20 C.)	Thermal Conductivity (Cal. per Sq. Cm. per Sec. per Deg. C. at 20 C.)	Relative Suitability for Being Worked		Best Temperature for Hot Working (Degrees Fahrenheit)	Approximate Annealing Range (Degrees Fahrenheit)	RELATIVE SUITABILITY FOR BEING WELDED				Relative Machinability (Free Cutting Brass = 100)
Commercial Sheet Stock — Approx. 0.040-in. Thick		Commercial Rod Stock — Approx. 1-in. Dia.		Commercial Sheet Stock — Approx. 0.040-in. Thick		Commercial Rod Stock — Approx. 1-in. Dia.								Cold	Hot			Gas (Oxy-Acetylene)	Carbon Arc	Metallic Arc	Resistance	
Hard (*)	Soft	Hard (*)	Soft	Hard (*)	Soft	Hard (*)	Soft															
4	48	..	..	B75	F60	....	....	16.0	17.8	0.321	1970	43	0.52	A	B	1450–1550	800–1450	B	C	C	C	30
8	47	..	..	B88	B25	....	....	15.0	19.0	0.320	1920	13	0.15	A	D	.....	850–1450	C	B	B	B	20
8	45	25	..	B90	B25	....	....	15.0	17.8	0.320	1920	18	0.20	A	D	.....	850–1450	B	C	C	B	20
10	70	..	..	B93	B38	....	....	14.0	18.2	0.318	1875	13	0.15	B	D	.....	850–1450	B	C	C	A	20
12	65	..	..	B96	B52	....	....	14.0	18.3	0.317	1830	11	0.12	C	D	.....	850–1450	B	C	C	A	20
8	45	25	..	B90	B25	....	....	15.0	18.0	0.322	1920	18	0.20	C	D	.....	850–1450	D	D	C	D	50
..	..	20	..	....	....	B75	....	15.0	....	0.320	1830	12	0.13	C	D	.....	850–1450	D	D	C	D	100
15	57	12	60	B95	B50	B100	B55	15.6	17.5	....	....	..	....	A	D	.....	550–1150	D	D	D	D	20
7	42	..	..	B88	B30	....	....	17.0	19.0	0.313	1850	8	0.11	A	D	.....	950–1550	B	D	D	A	20
8	40	..	..	B90	B33	....	....	18.0	18.0	0.314	1970	6	0.08	A	D	.....	1000–1550	B	D	D	A	20
5	40	..	..	....	....	....	....	18.0	19.0	0.312	1885	7	....	A	D	.....	1000–1550	B	D	D	A	20
4	40	..	..	B90	B40	....	....	18.0	18.0	0.316	2030	6	0.08	A	D	.....	1100–1550	B	D	D	A	20
2	45	..	..	B94	B40	....	....	18.0	19.0	0.314	1930	6	....	A	D	.....	1000–1550	B	D	D	A	20
4	35	25	45	B85	B25	....	....	19.0	16.4	0.320	2100	6	0.09	A	B	1600–1800	1150–1600	B	C	C	A	20
4	40	..	..	....	....	....	....	17.0	....	0.314	1900	7	0.10	B	D	.....	950–1550	C	D	D	D	50
5	..	..	..	B88	....	....	....	17.0	....	....	....	..	....	C	D	.....	950–1550	C	D	D	D	60
..	..	20	..	....	....	....	....	18.0	....	0.317	....	6	0.09	B	D	.....	1100–1550	C	D	D	D	50
..	..	..	..	....	....	....	....	....	20.0	0.306	1715	..	....	D	B	1300–1500	.....	C	D	D	D	80
..	..	..	..	....	....	....	....	....	20.0	....	1700	..	....	D	B	1300–1500	.....	C	D	D	D	50
..	..	..	..	....	....	....	....	....	20.0	....	1695	..	....	D	B	1300–1500	.....	B	D	D	C	30
4	30	..	..	....	....	....	....	18.0	....	0.323	2150	8	0.11	A	B	1600–1800	1050–1600	B	D	B	B	20
4	40	..	..	....	....	....	....	19.0	16.0	0.323	2190	6	0.09	A	B	1650–1850	1100–1650	B	D	B	B	20
5	40	..	..	....	....	....	....	20.0	16.0	0.323	2240	5	0.07	B	B	1700–1900	1100–1650	B	D	A	A	20
2	50	2	50	B95	B30	....	....	21.0	16.0	0.321	2200	5	0.07	A	A	.....	1300–1500	B	D	A	A	20
7	70	20	..	B92	B20	....	....	15.0	....	0.295	1940	18	0.20	A	B	1450–1700	950–1500	D	B	D	C	20
7	60	20	60	....	....	B90	....	15.0	17.9	0.281	1905	15	0.17	B	B	1450–1700	950–1500	D	B	D	B	20
..	..	35	..	....	....	....	....	....	16.9	0.274	1910	13	0.14	D	A	1450–1700	950–1500	D	B	D	B	20
..	..	15	..	....	....	....	....	18.0	....	0.274	1930	..	....	D	A	1450–1700	950–1500	D	B	D	C	20
7	45	..	..	B90	F72	....	....	....	17.0	0.302	2000	15	0.16	A	B	1400–1700	950–1500	B	B	B	A	20
..	..	10	38	....	....	B95	F68	....	16.7	0.315	2055	13	0.14	A	A	1400–1700	950–1500	B	B	B	A	20
8	60	20	85	B92	B35	....	B35	15.0	18.0	0.308	1865	6	0.08	A	A	1200–1500	850–1450	A	A	A	A	30
..	..	20	..	....	....	....	....	15.0	18.0	0.308	1865	6	0.08	B	D	.....	850–1450	C	C	B	D	60
8	46	12	60	B77	....	....	....	15.0	17.9	0.316	1930	12	0.13	A	A	1200–1500	850–1450	A	A	A	A	30
5	40	10	35	B78	B25	B80	B30	15.0	17.9	0.317	1905	13	0.15	A	B	.....	750–1470	B	B	B	B	20
5	35	22	45	B92	B45	B90	B45	15.0	17.9	0.309	1875	7	0.08	B	B	.....	750–1470	A	A	A	A	25
..	..	12	25	....	....	B95	B85	14.0	17.9	0.278	1814	7	0.08	D	A	1290–1380	.....	..	..	..	..	70
10	65	35	..	B91	F75	B90	....	....	18.0	0.310	1880	7	0.08	A	A	1250–1500	842–1382	A	A	A	A	30
..	..	35	..	....	....	B90	....	....	18.0	0.310	1880	7	0.08	B	C	1400–1500	842–1382	C	C	B	D	60
12	55	..	..	....	F83	....	....	....	19.3	0.308	1775	13	....	A	A	1350–1500	842–1382	A	A	A	A	30
5	65	10	65	B95	B45	B95	B45	15.0	17.0	0.308	1840	8	0.09	B	B	1350–1450	1022–1382	A	A	A	A	30
10	65	10	65	B95	B27	B85	B27	15.0	17.3	0.313	1895	11	0.12	A	B	1350–1450	1022–1382	A	A	A	A	30
5	65	10	65	B95	B45	B95	B45	15.0	18.0	0.308	1865	7	0.08	B	B	1350–1450	850–1450	A	A	A	A	30
10	65	10	65	B95	B27	B85	B27	15.0	18.0	0.316	1930	12	0.12	A	B	1350–1450	850–1450	A	A	A	A	30
20	60	20	75	....	....	....	....	15.0	....	0.317	1940	13	....	A	A	1200–1450	750–1350	B	A	B	A	25
8	55	20	75	B92	B50	B90	B50	15.0	17.3	0.309	1870	7	0.08	A	A	1200–1450	750–1350	B	A	B	A	25
..	..	20	75	....	....	B90	B50	15.0	....	0.312	1875	8	....	B	D	1200–1450	750–1350	B	A	B	A	65
15	55	20	75	B90	B50	B90	B50	15.0	17.3	0.313	1875	8	0.08	A	A	1200–1450	750–1350	B	A	B	A	30
..	..	11	40	....	....	B84	B55	21.0	....	0.302	....	..	....	A	B	1250–1450	600–1300	..	..	..	..	100
4	42	..	..	G84	B70	....	....	17.2	18.0	0.297	1750	17	0.25	B	B	1050–1425	1450–1550	D	B	D	B	..
2	5	..	..	G104	G102	....	....	18.4	18.0	0.297	1750	18-25	0.20	D	D	.....	.....	D	B	D	B	..
4	30	15	35	....	B60	B90	....	15.0	21.0	0.302	1645	25	0.24	D	A	1150–1350	.....	A	D	D	C	30

Note (†): Average linear coefficient per degree Centigrade from 25 to 300 C. Tests on Rod. Scientific Paper No. 410, U. S. Bureau of Standards. — Relative hot and cold working and weldability ratings are indicated as follows: A = Excellent, B = Good, C = Fair, and D = Poor.

FORMING AND PRESSING OPERATIONS

Workability and machinability characteristics of the tin, nickel, manganese, aluminum, beryllium and silicon alloys of copper vary over a wide range. Most of the alloys are more easily cold worked than hot worked. Relative suitability of the various alloys for both cold and hot working are indicated in the table on pages 646 and 647 of this section.

HOT WORKING

Hot forging can be done on drop hammers, percussion presses, power presses or forging machines when dies are use. Most brasses and bronzes, however, are forged in mechanical presses with one stroke of the press finishing the piece from the heated slug. The action usually is a combination of displacement and extrusion processes.

Proper die design is essential to the production of sound forgings. Those for forging brasses and bronzes usually differ from dies made for forging steel only in the matter of finish. Surfaces must be free from scratches in order to insure smoothly-finished forgings. Shrinkage, draft and finish allowances ordinarily are the same as for steel forgings.

Hot pressed parts ordinarily are made in solid shapes, although within certain limitations they can be cored in one direction. Pressure die castings sometimes are made from a "bronze" alloy containing about 81.5 per cent copper, 14.1 per cent zinc, 4.25 per cent silicon and 0.15 per cent manganese. While these die castings are less dense in grain structure than hot pressed parts, they are adaptable to a wider range of design.

Beryllium copper can be hot worked by drop forging, hot pressing, upsetting or extruding. Working temperatures should be established between 1,050 and 1,425 F. and, because of the rapid cooling rate of this material, it is best to heat to the top of the range. Care must be taken to work the metal only within the forging range to avoid hot and cold shorts. Where steel can be given 12 to 15 hammer blows, beryllium copper must be limited to 4 or 5 light blows, reheated, and hammered again. Hot pressing is preferable to hammering when the nature of the work permits.

After hot forming beryllium copper a *homogenizing* treatment is used to restore the super-saturated *alpha* solution necessary for precipitation hardening. This treatment consists of heating at 1,430 to 1,470 F. for two or preferably three hours and then quickly quenching in water.

COLD WORKING

In cold working operations the metal is not preheated above room temperature, although the operation may raise the temperature of the metal appreciably. Practically all of the so-called bronze alloys may be readily cold worked within the limits of the *alpha* solid solubility of the alloying elements.

Generally speaking, to be successfully cold worked the metal must show in physical tests at room temperature an appreciable elongation and reduction of area. There are many cases in which the type of lubricant used has been found to be important in the success of cold working operations. Also, the surface condition of the material may cause difficulties. Oxides should be removed by pickling prior to cold working.

For beryllium copper, parts that are capable of being wrought by a cold-working process are preferably worked cold. This makes it possible to take advantage of the work-hardening properties of the metal and, in addition, to obtain the additive hardness and strength of the subsequent heat-treatment.

Punches and dies of high-carbon, high-chromium steel are used with clearances the same as for blanking strip steel when punching and blanking beryllium copper. These tools stand up well providing the strip or sheet is cadmium plated before blanking. This plate provides proper lubrication for the punch and die.

All types of copper-silicon alloys are readily cold worked. Rod drawn to a tensile strength of 85,000 lb. per sq. in. can be cold headed and roll threaded for bolts. In the cold heading of these bronzes, it is best to facilitate the flow of metal into the head and reduce possible stress concentration by incorporating a small fillet under the head. A fillet of $\frac{1}{16}$ in. minimum radius for bolts up to $\frac{1}{16}$ in. diameter and $\frac{1}{32}$ in. minimum radius for larger bolts is sufficient.

When punching and blanking bronzes the tools ordinarily are made with the same clearances as those used for cold rolled steel of the same thickness. For forming and drawing operations, however, larger radiuses are required in order to prevent "orange peel" and cracks.

Progressive, multiple-station machine operations are gaining favor, particularly for the drawing, forming and blanking of small parts. This method eliminates the need for an intermediate anneal as the amount of cold working in each successive step is less than if each operation were performed on a separate machine.

Many forming and drawing jobs can be done dry, but best results and longer die life will be obtained by using lubricants. For most drawing operations, a 3 per cent aqueous solution made from soap chips will be satisfactory. The solution should be kept warm to prevent it from forming a gel. Prior to drawing the metal can be dipped into the solution and drained, or the solution can be applied with rollers as the strip is fed into the press. For heavy draws, oils sometimes are used.

Spinning lathes can be used for spinning, burnishing, trimming and curling operations. The 18 per cent nickel silver alloy frequently is used in the manufacture of spun parts, both because of its good forming properties and its color. Other nickel silvers and a number of other bronzes also can be spun.

ANNEALING

An anneal involves the application of heat to a strain-hardened metal in order to release or dissipate the stresses, form new grain structures and produce a softer or more ductile material. Optimum annealing ranges for many of the bronze alloys are given on page 647. In annealing alloys of high nickel content it is customary to protect them from oxidation by pack annealing or by using controlled atmospheres that are non-oxidizing and sulphur-free. It is recommended that oil lubricants be removed before annealing to prevent the formation of carbonaceous deposits on the metal.

Leaded nickel silvers are very sensitive to heat. The alloys must be brought up to annealing temperature slowly and cooled slowly, as fire cracking may result because of rapid temperature changes.

The annealing of beryllium copper during a series of cold working or forming operations, so as to soften the alloy for further cold working, is accomplished by heating to a temperature of about 1,475 F., holding it

APPLICATIONS of TYPICAL WROUGHT BRONZES and OTHER COPPER ALLOYS

TYPICAL WROUGHT BRONZES and OTHER COPPER ALLOYS Not including the Wrought Coppers and Copper-Zinc Alloys (Brasses) previously discussed (*A. M.*— Vol. 82, page 1101). Commonly Used Trade Names	Forms Commonly Available: Plate — Sheet — Strip	Wire	Rod — Bar	Tube	Extruded Shapes	Forgings — Hot Pressings	CHIEF CHARACTERISTICS	TYPICAL APPLICATIONS
Tin or Phosphor Bronzes								
Phosphor Bronze	●	●	●	●			Moderately high conductivity	Welding rod, screen cloth, flexible metal hose.
4% Phosphor Bronze (Grade A)	●	●	●	●			High resistance to abrasion, retains elasticity under repeated bendings.	Springs, electric switches.
5% Phosphor Bronze (Grade A)	●	●	●	●			High resistance to abrasion, retains elasticity under repeated bendings.	Springs, electric switches.
8% Phosphor Bronze (Grade C)	●	●	●	●			High strength and toughness	Recommended where high elastic limits are required and where metal must be formed.
10% Phosphor Bronze (Grade D)	●	●	●	●			High spring qualities and resiliency	Recommended for parts requiring little or no forming.
Leaded Phosphor Bronze (Grade B)	●	●	●	●			Includes lead to give improved machining characteristics.	Screw machine products.
Free-Cutting Phosphor (Bushing) Bronze	●		●				Can be machined almost as easily as free-cutting brass rod.	Can be used for bearings, gears, ratchet wheels, bushings, valve and pump parts.
"Carobronze" Bearing Alloy	●		●	●	●		Has good bearing properties, high resistance to shock loads and to corrosion.	Bearings, pump and compressor liners, parts subject to abrasion.
Nickel Silvers								
10% Nickel Silver	●						Malleable alloy suitable for forming, drawing and spinning.	Frequently used for cheaper grades of silver-plated ware.
15% Nickel Silver (64% Copper)	●	●	●				Malleable alloy suitable for forming, drawing and spinning.	Silver-plated ware.
15% Nickel Silver (57% Copper)	●	●	●	●			Malleable alloy suitable for forming and stamping.	Plumbing fixtures and architectural trim.
18% Nickel Silver (65% Copper)	●	●	●				Malleable alloy suitable for forming, drawing and spinning.	Silver-plated ware, auto and boat trim.
18% Nickel Silver (55% Copper)	●						Has good spring qualities, is easily worked.	Springs, electric resistance wire or strip.
20% Nickel Silver (See Note A)	●	●	●	●		●	Can be bent, stamped, spun, formed, drawn, hot forged, double seamed.	Used for ornamental purposes and for heat exchanger tubes.
12% Leaded Nickel Silver	●	●	●				Free machining	Keys and hardware.
12.5% Leaded Nickel Silver	●						Free machining	Watch parts.
18% Leaded Nickel Silver		●	●				Free machining	Hardware.
10% Extruded Nickel Silver			●		●	●	Free machining	Extruded shapes, screw machine products.
13% Extruded Nickel Silver			●		●		Free machining	Architectural shapes, automobile hardware.
13% Extruded Nickel Silver			●		●		High malleability	Architectural shapes.
Cupro — Nickels								
15% Cupro — Nickel	●	●	●				Highly ductile and malleable, good corrosion resistance.	Bullet jackets.
20% Cupro — Nickel	●	●	●	●			Highly ductile and malleable, good corrosion resistance.	Projectile rotating bands, condenser tubes, turbine blades.
30% Cupro — Nickel	●	●	●	●		●	Can be hot forged, cold rolled and drawn. Readily soldered, brazed or welded.	Containers for corrosive substances, condenser tubes.
Copper — Nickel — Tin (Adnic)	●	●	●	●			High strength, ductility, malleability and corrosion resistance.	Corrosion resistant diaphragms, containers, and condenser tubes.
Aluminum Bronzes								
5% Aluminum Bronze	●	●	●	●		●	High strength and corrosion resistance	For forgings and for its color; condenser tubes.
8% Aluminum Bronze	●	●	●				High strength and corrosion resistance	For corrosion resistance.
Nickel — Aluminum Bronze			●			●	High strength and corrosion resistance	For forgings, valve seats and bushings.
5% Nickel — Aluminum Bronze			●				High strength, hardness and corrosion resistance.	For shafting and engineering purposes.
Nickel — Aluminum Bronze (Type A)	●			●			Ductile and malleable, can be severely cold worked, good mechanical properties.	Condenser plates and tubes, heat exchanger tubes, ferrules.
Nickel — Aluminum Bronze (Type B)	●		●			●	Soft and ductile as quenched, may be cold worked extensively, heat-treatable.	Bearing plates, marine hardware, pickling racks, valve stems, forgings, pump rods.
Copper — Silicon Alloys								
Everdur No. 1010 (See Note A)	●	●	●	●		●	The basic Everdur alloy; has high strength and good corrosion resistance.	Tanks, sewage disposal equipment, hot headed bolts, valve stems.
Everdur No. 1012			●				Includes lead to give improved machining characteristics.	Screw machine products.
Everdur No. 1015 (See Note A)	●	●	●	●		●	Modification of basic alloy developed to facilitate cold working.	Cold headed bolts, nuts.
Duronze I	●	●	●			●	Has high strength; very malleable even when hard drawn.	Bolts, nuts, cold forgings, wire and cable clamps, washers, gears, shafts.
Duronze II	●	●	●			●	Has the strength and toughness of mild steel; corrosion resistance high.	Tanks, ducts and flues; hot forgings, bolts, nuts, clamps, screws, springs.
Duronze III (Silicon — Aluminum Bronze)	●		●			●	Strong and hard, free machining, hot forged easily.	High-strength forgings, screw machine products, gears, valve parts.
Olympic Bronze — Type A	●	●	●	●		●	Readily hot and cold worked, readily welded by all processes.	Angles, bearing plates, bolts, clamps, drawn and stamped parts, forgings, shafts.
Olympic Bronze — Type D			●				Good machinability attained at some sacrifice of working properties.	Screw machine products.
Olympic Bronze — Type G (Silicon Brass)	●						Drawing and stamping properties good	Hardware, hinges, kickplates, sheathing, springs.
Herculoy No. 418	●		●	●			Hot-works readily, non-magnetic	.....
Herculoy No. 419	●		●	●			Can be cold worked severely, non-magnetic.	.....
Herculoy No. 420	●		●	●			Hot-works readily, non-magnetic	.....
Herculoy No. 421	●		●	●			Can be cold worked severely, non-magnetic.	.....
P-M-G No. 3	●	●	●	●		●	Fairly high tensile strength, high conductivity. Cold works well.	High tensile wire, railway signal bonds, screws, rivets, bolts, nails.
P-M-G No. 10	●	●	●	●		●	Extremely tough, corrosion resistant, ductile.	Tanks, vats, hot headed bolts, pump rods, pistons.
P-M-G No. 95			●				Modification of basic P-M-G alloy to improve machinability.	Screw machine products.
P-M-G No. 96	●	●	●	●		●	Very ductile, has high tensile strength	Cold headed bolts, cold forged nuts, tubing, electrical hardware.
Other Alloys								
Arsenical Bronze			●				Free machining; has high resistance to temperature, wear, and corrosion.	Valve stems.
Beryllium Copper (See Note A)	●	●	●			●	Has high tensile strength. Can be heat treated.	Wide range of applications; used for nozzles, gears, springs, contact fingers, firing pins; non-sparking wrenches, chisels and other tools.
Beryllium Copper (Precipitation Hardened)	●	●	●			●	High strength, hardness, fatigue limit and corrosion resistance.	
Manganese Bronze	●	●	●		●	●	Has high strength and resistance to corrosion.	Forgings, bolts, valve stems, screens.

Note A: Available only in simple shapes.

Suggested Coolants and Lubricants for Copper Alloys

OPERATIONS	Manganese Bronze	Phosphor Bronze	Aluminum Bronze	Silicon Bronze	Nickel Silver	Cupro-Nickel	Beryllium Copper	Copper	Brass
Turning	A15 L20 MS	A15 L20 MS	A15 L20 MS	A15 L20 MS	A25 L10 LS	 A15 HS		 A15 HS	A25 L10 LS
Boring	A15 L20 MS	A15 L20 MS	A15 L20 MS	A15 L20 MS	A25 L10 LS	 A15 HS		 A15 HS	A25 L10 LS
Drilling	A15 L20 MS	A15 L20 MS	A15 L20 MS	A15 L20 MS	A25 L10 LS	 A15 HS		 A15 HS	A25 L10 LS
Reaming	HS	HS	HS	HS	MS	HS		HS	MS
Machine Tapping	MS	MS	MS	MS	LS	MS		MS	LS
Hand Tapping	HS	HS	HS	HS	MS	HS		HS	MS
Milling	A15 L20 MS	A15 L20 MS	A15 L20 MS	A15 L20 MS	A25 L10 LS	A15 L20 MS		 A15 HS	A25 L10 LS
Broaching	HS	HS	HS	HS	MS L20	HS BS		HS BS	A15 L20 MS
Grinding	A100 B	A100 B	A100 B	A100 B	A120 B	A100 B	B	A100 B	A120 B
Screw Machine Operations	HS	HS	HS	HS	LS L10	HS		HS	L10 LS
Sawing	A20 HS	A20 HS	A20 HS	A20 HS	A25 L20 MS	A20 HS	B	A20 HS	A25 L20 MS
Punching	L20 MS	L20 MS	L20 MS	L20 MS	L10 LS	L20 MS		L20 MS	L10 LS
Blanking	L20 MS	L20 MS	L20 MS	L20 MS	L10 LS	L20 MS		L20 MS	L10 LS
Drawing	HS	HS	HS	HS	L20 MS	HS		HS	L20 MS
Cold Heading	HS	HS	HS	HS	L20 MS	HS		HS	L20 MS

KEY TO SUGGESTED COOLANTS AND LUBRICANTS

Fluid	Symbol	Fluid	Symbol	Fluid	Symbol
1 to 15 Soluble Oil Mixture	A15	1 to 120 Soluble Oil Mixture	A120	Medium Sulphur Oil	MS
1 to 20 Soluble Oil Mixture	A20	10 Per Cent Min. Lard Oil..	L10	High Sulphur Oil...	HS
1 to 25 Soluble Oil Mixture	A25	20 Per Cent Min. Lard Oil..	L20	Base Sulphur Oil...	BS
1 to 100 Soluble Oil Mixture	A100	Low Sulphur Oil.....	LS	Mineral Seal Oil....	B

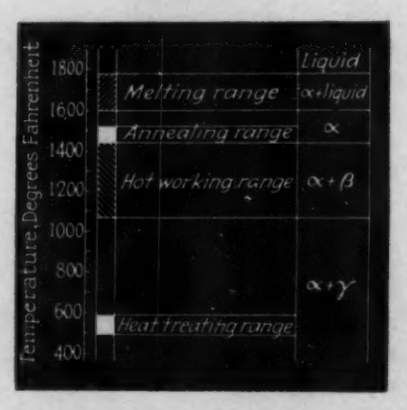
there for 15 to 30 min., and then immediately quenching in cold water. The heat causes recrystallization, while the quench preserves the supersaturated *alpha* structure.

Copper-silicon alloys will recrystallize after severe cold working at about 750 F. and at slightly higher temperatures following more moderate reductions. Annealing temperature should be selected according to the size or thickness of the piece and the degree of softness desired.

HEAT-TREATING

Aluminum bronzes generally are not heat-treated unless their aluminum content is as high as 10 per cent. Heat-treatment usually consists of quenching in water from 1,500 to 1,600 F., depending on the cross section. This is followed by tempering between 700 and 1,100 F. Cooling in air from the quenching temperature without tempering often is done.

Heat-treatment of beryllium copper consists of heating the articles to 500–575 F. and cooling them in air or in any convenient way. Time of heating must be predetermined and accurately regulated in order to control quantity, particle size and distribution of the precipitates. Heating can be accomplished in a muffle furnace, salt bath, or oil bath, if accurate temperature control is provided.



Temperature ranges important in the fabrication and heat-treatment of beryllium copper are indicated on this chart. Time of heat-treatment is regulated accurately for best results

The period of time for which beryllium copper is held at the heat-treating temperature is governed by the properties desired and the cold-worked hardness of the metal. The effect of increased tempers due to cold working is to shorten the heat-treating cycle. However, the use of extreme cold working tempers is not recommended as a means of shortening heat-treating time.

PICKLING

Oil, grease and soap should be removed before annealing or heat-treating, as this will assist in obtaining clean surfaces when pickling. Upon heating, a greasy material will form a gummy film on the surface which will prevent the pickling solution from reaching the metal.

The scale formed by annealing, forging or heat-treating beryllium copper can be removed quickly and thoroughly by a 3 to 5 min. immersion in a warm solution made by pouring two parts of commercial concentrated sulphuric acid into one part of water. This solution is very corrosive and must be handled cautiously.

If a weaker solution is desired, the work may be left for 5 or 6 hr. in a solution made up of 1 part sulphuric acid and 10 parts of water. This treatment leaves a red copper film on the surface which can be removed by a quick immersion in the usual nitric acid bright dip. It also can be removed by dipping in an acid solution composed of 1½ to 2 lb. sulphuric acid and 2 to 3 lb. potassium bichromate for each cubic foot of water.

The oxide normally formed on copper-silicon alloys during an annealing operation is particularly tenacious and a pickle solution containing 10 to 20 per cent sulphuric acid leaves a thin, dark red oxide coating on the metal. Except where a bright surface is wanted for its color, or for welding, this red pickled finish is satisfactory.

The pickled copper-silicon alloy can be bright dipped in a solution composed of 15 per cent sulphuric acid and ¾ lb. per gal. of sodium bichromate. The solution should be held at about 100 F. for best results. After removal from this solution, the metal should be thoroughly rinsed in cold water and then dipped for a few seconds in a solution composed of 15 per cent sulphuric acid and 2 per cent commercial hydrofluoric acid. Next it should be given a thorough rinsing in cold water to remove any white deposit still clinging to the metal.

MACHINING AND FINISHING OPERATIONS

Not readily defined, machinability usually is described in terms of its effect on cutting properties and the conditions under which cutting operations are performed. For the wrought copper alloys commonly referred to as bronzes, this characteristic is dependent upon composition to a greater extent than on mechanical properties.

A few of the wrought bronze alloys, as indicated in accompanying tables, are as easy to machine as free-cutting brass. Others present problems of tool shapes, tool material, coolant and cutting speed that can be solved only by actual trial on the machine selected for the operation. A number of these alloys are similar in cutting characteristics to mild alloy steels.

COOLANTS

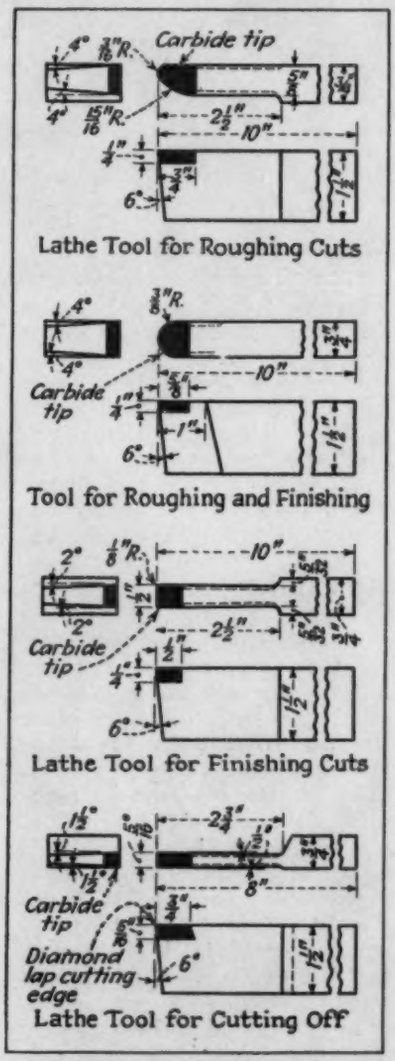
Resistance to cutting ordinarily is high in the refractory bronzes, and most of them have abrasive characteristics. Hence, tool wear is more rapid than for most of the other alloys of copper. The use of a cutting fluid which combines good cooling and lubricating properties will result in higher tool life. Flow of the coolant should be copious and uninterrupted. Sulphurized oils may discolor the work, especially when heavy cuts are taken, and should be removed soon after the operation is completed. Discoloration caused by sulphurized oils may be removed by soaking the pieces in a 5 to 10 per cent solution of sodium cyanide.

Owing to the widely varying requirements of different cutting operations, most of the suppliers of coolants and cutting lubricants advise that it is practically impossible to standardize on specific coolants for operations on the various bronzes. They employ technical staffs whose business it is to develop proper technique for the various operations as performed in individual plants. The cutting lubricants suggested in the accompanying table should be considered as starting points in selecting a fluid.

TURNING AND BORING

Leaded or free-cutting bronzes machine much like free-cutting brasses and the same type of tools are used. Refractory alloys ordinarily are machined at slower speeds and with tools ground with larger top and side rake angles. Some workers in these materials, however, recommend the use of tools with small rake angles, the same as would be used for brass, and adjusting the speed and feed according to the machinability of the material.

Most silicon bronzes are rated only fair in machinability. High-speed steel or carbide-tipped tools ordinarily are used. One supplier suggests a back rake of 10 deg., side rake of 6 deg., and 10 deg. clearance angles; another reports that a back rake of 7 deg. is satisfactory for roughing tools and 12 deg. for finishing tools, with side rakes of 8 to 12 deg. and an 8 to 12 deg. clearance angle. Form tools ordinarily have a back rake of 10 deg.



Tools used for free-machining bronzes are of the same type as those recommended for brasses. Some fabricators also use these tools for the refractory bronzes to prevent the tool from "hogging in" during the cut

MILLING OPERATIONS

Clearance behind the cutting edge on milling cutters must be sufficient to avoid rubbing, but not so great as to allow the cutter to "hog in." A clearance angle of 10 to 12 deg. will work well with brass and soft bronze. This should be reduced to 4–7 deg. for the medium and hard bronzes. Width of land should be kept at $\frac{1}{32}$ to $\frac{1}{16}$ in., depending on cutter size.

For aluminum and silicon bronze, coarse-tooth helical cutters with considerable top rake are recommended. Milling speeds of as much as 50 to 100 ft. per min. with feeds of 10 to 20 in. per min. are used. Helical and staggered-tooth cutters work well on nickel silvers and cupro-nickels at about 60 to 70 ft. per min. with a sulphur-base oil as a lubricant.

Beryllium coppers can be milled with helical cutters at 80 to 90 ft. per min. using mineral lard oil. One company has found that a 0.001 in. thick cadmium plate on a beryllium copper contact roll increased production from 7 to 60 rolls per cutter grind in a thread milling operation.

SAWING

Bandsaws for cutting manganese bronze should have about 10 to 14 teeth per inch, with "raker" set (one tooth to left, next tooth straight, and next tooth to right, etc.), and under average conditions should operate at 150 to 350 ft. per min. Nickel silver is cut with bandsaws having 18 to 22 teeth per inch, with a "straight" set (teeth set alternately right and left), operating at about 150 to 175 ft. per min. Copper-silicon alloys take saws with 10 to 12 teeth per inch, raker set, running 150 to 350 ft. per min. Hand or power feed may be used. Beeswax sometimes is used to lubricate the saw, but cutting usually is done without a lubricant.

Solid-tooth, high-speed steel circular saws used for bronze may have either straight or "topped" teeth ground radially if the saw arbor is above the work, or with a 10 deg. hook when the arbor is below the work. Speeds of 400 to 600 ft. per min. can be used with feeds of up to 30–50 in. per min. Rate of feed can be increased with increases in saw thickness.

SPEEDS AND FEEDS FOR CARBIDE-TIPPED TOOLS

Type of Cut	Depth of Cut (Inch)	Maximum Feed (Inch)	Range of Cutting Speeds (Feet per Minute)		
			Copper	Brass and Bronze Hard	Brass and Bronze Soft
Extra Heavy	1/4–3/4	1/32	60–100	60–100	100–400
Heavy	3/16–1/2	1/16	60–100	60–150	100–400
Heavy-Medium	1/4–3/8	3/64	60–100	60–150	100–400
Medium	1/8–1/4	1/32	60–150	60–150	100–400
Medium-Light	1/16–1/8	1/32	200–500	80–200	150–400
Light	1/32–1/16	0.020	200–500	100–250	150–400
Light Finishing	1/64–1/32	0.010	200–500	100–250	250–400
Precision Boring	0.005–0.01	0.005	800–1600	400–1000	800–1600

Carbide-tipped turning tools have been used advantageously for the machining of coppers, brasses and bronzes. Their chief advantage is increased production between grinds

BROACHING

As far as broaching is concerned, the bronze alloys fall into two classifications. The deciding factor is whether they roll up a continuous, sturdy chip or whether the chip is loose and broken up. The chip characteristic fixes the treatment of the broaches at about the same procedure as used for cast iron and steel.

Cutting angles on broaches are determined by the chip characteristic which is related to the ductility of the material. On the brittle alloys front clearance angles of 0 to —5 deg. are used. Back clearance angles are held between 1½ to 2½ deg.

DRILLING

Recommendations given for drilling brass (*AM*—Vol. 82, page 1109) apply to all of the free-cutting bronzes and most of the refractory alloys. High-speed steel drills with narrow lands and polished flutes usually give best results. Included point angles range from 100 deg. for beryllium copper to 118 deg. for nickel silvers, aluminum bronzes and copper-silicon alloys. Point clearance angles should be about 10–15 deg. For many operations the cutting edges should be "flatted" slightly, as for brass.

It is important to apply sufficient pressure to keep the drill cutting constantly, particularly for the alloys that work-harden readily. If this is not done "glazing" and hardening of the work will make it difficult to resume cutting. The use of a lubricant is important; for large-diameter holes the use of oil-tube drills with lubricant supplied under pressure is recommended.

Aluminum and silicon bronzes usually can be drilled at speeds of 60 to 75 ft. per min. or more with a lubricant consisting of ⅓ kerosene and ⅔ lard oil. Speeds of 80 to 90 ft. per min. can be used for nickel silvers and cupro-nickels with a sulphur-base oil lubricant.

As in drills and taps, narrow lands and well polished flutes aid in reaming operations. A zero rake angle on the cutting point and increased clearance angles give best results.

Straight-flute or left-hand spiral, right-hand cut high-speed steel reamers cleared up to a sharp edge give good results in nickel silver aluminum bronze and copper-silicon alloys. Speed for aluminum bronze should be about 150 ft. per min., for silicon bronze use 100 ft. per min., with a mixture of lard oil and kerosene as a lubricant. Speeds of 40–50 ft. per min. are recommended for nickel silvers and cupro-nickels.

For beryllium copper, high-speed steel reamers cleared up to a sharp edge and given a special heat treatment after finishing for increased surface hardness, result in longer reamer life. Speed should be about 80 ft. per min. with soluble oil as a lubricant.

THREADING

Properly ground taps and chasers, proper cutting speeds and a carefully selected lubricant are necessary for threading bronze alloys. Spiral pointed taps are recommended for through holes in beryllium copper. For blind holes in this alloy use high-speed steel, right-hand cut ground-thread taps having a right-hand spiral at 50 to 60 ft. per min. with lard oil.

High-speed, spiral-point, ground-thread taps having two or three flutes are recommended for nickel silvers and cupro-nickels. Tapping speed should be 70 to 80 ft. per min. with a sulphur-base oil. For aluminum bronze, use right-hand spiral, right-hand cut taps at about 150 ft. per min. Use a lubricant consisting of ⅓ kerosene and ⅔ lard oil for this material.

Two, three or four fluted taps can be used for copper-silicon alloys, depending on the size of the tap, if the lands are narrow and the flutes deep. Flutes, according to some users, should have a radial face. Others recommend a lip or "hook" of 10 to 15 deg. Oversize taps should be used. Use a two thread chamfer on the end to overcome work-hardening of the material. One supplier recommends tapping speeds of 60 to 65 ft. per min. when using a kerosene and lard oil mixture.

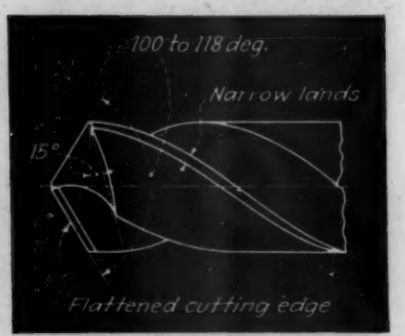
Recommendations for thread chaser angles vary. One is that chasers have a rake angle of 10 to 15 deg. with surface speeds of 15 to 20 ft. per min. for copper-silicon alloys. Others recommend rake angles as high as 20 deg. One manufacturer of die heads recommends a rake angle of 10 deg. and speeds of 50 to 80 ft. per min., depending on diameter, for phosphor bronzes.

FILING

An open-cut file having a very light up-cut usually works best when filing brasses and bronzes. Trouble often is caused by the tendency for chips to clog up the file and cause scratches in the material. The open-cut file reduces this to a minimum. Finish obtained is governed by fineness or coarseness of the file cut. Speed, when hand filing, should be the same as for steel. About 120 strokes per minute seems to be the proper speed for machine filing.

GRINDING

Selection of grinding wheels for a given bronze alloy depends upon such variable factors as: (1) size and shape of piece, (2) its hardness and other physical characteristics, (3) amount of material to be removed, (4) finish desired, (5) whether grinding is to be performed wet or dry, (6) nature



Drills for the various bronzes usually are ground as shown. Cutting edges are flatted for the free-machining alloys, but usually are left sharp for the more refractory bronzes

of grinding operation, (7) condition of machine, and (8) production requirements. As a starting point, the previously published tabulation of suggested grinding wheels for copper alloys (*AM*—Vol. 82, page, 1110) will be helpful.

All grinding operations on bronzes should be performed wet, with an abundant supply of coolant furnished at the point of grinding. Where soft, ductile alloys are to be ground it may be necessary to employ a tallow or wax stick in order to keep the wheel face from loading.

Practically all of the so-called bronze alloys are readily cut off by the abrasive wheel method. Many of the alloys can be cut dry with resinoid-bonded wheels, but wet cutting is more suitable for the tougher alloys. Rubber-bonded wheels usually are used for wet abrasive cutting operations.

A surface speed of about 8,000 ft. per min. is used when wet cutting with abrasive wheels, this is increased to 16,000 surface ft. per min. for dry cutting. Coarse-grain wheels usually last longer but do not give as smooth a cut as do fine-grain wheels.

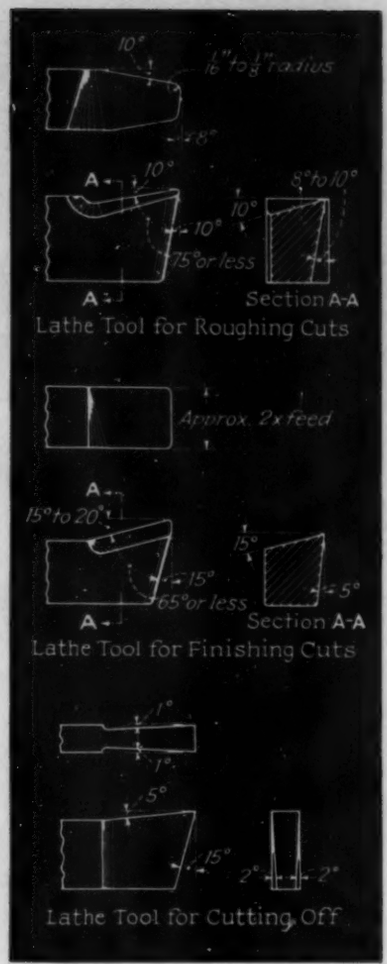
POLISHING

Solid abrasive wheels (usually aluminum oxide bonded with synthetic resins or rubber) are used for removing parting lines, fins, rough surfaces or deep pits. Care must be used in the selection of such wheels so that grain size will not be so coarse as to cause polishing marks.

A careful study should be made of subsequent polishing operations so that they will be selected with a view to economy of time and a minimum sequence of processing. Where fast cutting action and long abrasive life is desired, use artificial abrasive grains in "setting up" the wheel.

Often a combination of artificial abrasive grains in early operations and Turkish emery in final operations is desirable. Depending on the amount of polishing necessary, and the nature of the material, grain sizes for succeeding operations will run in about the following steps: Nos. 60, 90, 120 and 150 for roughing; and Nos. 180, 200 and 220 for finishing. If little cutting action is required at the start a grain size of 150 or 180 may be selected for the first operation.

Wheels set up with No. 150 grain or smaller usually are of the "grease" type to eliminate "drag" or grain marks, thus producing a smoother finish. Where the polishing operation is to be followed immediately by plating, a highly emulsifiable and readily



The refractory bronzes require larger tool rake and clearance angles than do the free machining alloys. Those shown above are the recommendations of one supplier of copper-silicon alloys

saponifiable tallow should be used.

Methods and materials used for buffing operations depend upon the final finish desired. Buffing generally is accomplished by using Tripoli in what is known as a "cutting down" operation.

Where a final lustrous finish is desired a "coloring" operation follows the preliminary buffing operations. Here white compounds or lime compositions are employed. Buffs used in both cutting down and coloring operations may be of the pieced, full disk, or gathered-bias type. Polishing usually is done at slow speeds, such as 1,800 r.p.m. for a 14-in. diameter wheel, while buffing is done at 2,500 to 3,600 r.p.m.

CLEANING

The cleaning of all metals for plating or lacquering is greatly simplified by selecting the proper buffing compositions or most easily removed lubricants. Cleaning solutions should be made up from well balanced compounds that have been developed especially for the metal to be cleaned. There is no "universal" cleaner. Oxide films are really metal films, and acid or cyanide dips used to remove these films must be strong enough to dissolve the oxide but must not attack the basic metal. Where a high luster is required care must be used not to form a discoloration on the metal. Rinse waters must be kept reasonably clean.

SOLDERING AND BRAZING

Practically all of the copper-base alloys are readily joined by soldering and brazing operation as outlined in the discussion of the working of coppers and brasses (*AM*—Vol. 82, page 1101). However, precautions are necessary when joining beryllium copper because of its low softening and heat-treating temperature ranges.

Soft soldering operations on beryllium copper ordinarily are performed after the parts have been heat-treated, since the temperature for the latter is above that for soldering. After the surface has been cleaned thoroughly, soldering is done in the usual manner. The part is kept as cool as possible so that its temper will not be changed. A solder containing 90 per cent tin and 10 per cent zinc makes stronger joints than the lead-tin solders.

In silver soldering beryllium copper, the work must be handled quickly and carefully to keep all parts of the work within the temperature range 1,436 F. (temperature at which beryllium copper is homogenized prior to hardening) and 1,587 F. (temperature at which beryllium copper starts to melt). The silver solder alloy selected must melt and flow freely below 1,587 F. and must be solid enough to withstand quenching at 1,436 F.

GAS WELDING

Lead usually will start boiling out of bronzes containing relatively high amounts of this element before the base metal reaches a red heat. This tendency is reduced by using an excess oxygen flame before both preheating and welding by the oxy-acetylene process. The Linde Air Products Company recommends the following procedure for determining correct flame adjustment:

"After the base metal has melted and there is a noticeable film on the surface of the molten puddle, the

SUGGESTED PROCEDURE FOR WELDING COPPER-SILICON ALLOYS

Metal Thickness Inches	CARBON ARC WELDING					METALLIC ARC WELDING				OXY-ACETYLENE WELDING			
	Number Beads	Welding Rod	Carbon Diam.	Welding* Current	Remarks	Number Beads	Welding Rod	Welding† Current	Remarks	Number Beads	Welding Rod	Tip Size	Remarks
1/16	1	1/16	1/4	100	Welding Speed 15 in. per Min.	1	1/16	125	Welding Speed 12 in. per Min.	1	1/16	4	———
5/32	1	5/32	1/4	125	Welding Speed 15 in. per Min.	1	5/32	200	Welding Speed 12 in. per Min.	1	3/32	5	———
1/8	1	5/32	5/16	140	Welding Speed 15 in. per Min.	1	5/32	200	Welding Speed 12 in. per Min.	1	3/16	6	1/16 in. Space Between Edges
5/32	1	3/16	5/16	200	Welding Speed 15 in. per Min.	1	3/16	230	Welding Speed 12 in. per Min.	1	3/16	7	3/32 in. Space Between Edges
3/16	1	1/4	3/8	225	Welding Speed 12 in. per Min.	1	1/4	260	Welding Speed 10 in. per Min.	1	3/16	8	1/16 in. Space Between Edges
	2	5/32	5/16	150		2	5/32	200					
1/4 Double V	3	1	1/16	5/16	150	3	1	1/16	125	1		3/16	8	45 deg. Bevel 1/16 in. Space Between Edges
		2	3/16	5/16	200		2	5/32	200				
		3	3/16	5/16	200		3	5/32	210				
1/4 Single V	3	1	1/16	5/16	150	3	1	1/16	125				
		2	5/32	5/16	180		2	5/32	200				
		3	3/16	3/8	220		3	3/16	235				
3/8 Double V	4	1	5/32	5/16	150	5	1	1/16	125	1		1/4	10	45 deg. Bevel 1/16 in. Space Between Edges
		2	5/32	5/16	180		2, 3	5/32	200				
		3, 4	1/4	3/8	250		4, 5	3/16	235				
3/8 Single V	4	1	1/16	5/16	150	4	1	1/16	125	2	1	3/16	8	Entire Length of Joint 1/8 Full Complete with Reinforcement
		2	5/32	5/16	180		2	5/32	200		2	1/4	10	
		3	3/16	3/8	220		3	5/32	210				
		4	1/4	3/8	275		4	3/16	235				
1/2 Double V	6	1	5/32	5/16	150	7	1	1/16	125	1		5/16	10	30 deg. Bevel 1/16 in. Space Between Edges
		2	5/32	5/16	180		2, 3	5/32	200				
		3, 4	3/16	3/8	225		4, 5	3/16	235				
		5, 6	1/4	3/8	300		6, 7	1/4	260				
1/2 Single V	5	1	5/32	5/16	150	6	1	1/16	125	2	1	1/4	8	Entire Length of Joint 1/8 Full Complete with Reinforcement
		2	5/32	5/16	200		2, 3	5/32	200		2	3/16	10	
		3	3/16	3/8	230		4	3/16	235				
	4, 5	1/4	3/8	300		5, 6	1/4	260					

* Short Arc 15 to 20 Volts † Arc Short as Possible - About 25 Volts

amount of excess oxygen in the flame should be varied over a fairly wide range, during which it will be observed that for one particular flame adjustment the film or coating tends to disappear and a bright surface is maintained on the metal. This is the correct flame adjustment for good welding of high tin, high lead copper alloys. Once this adjustment is found, welds free from holes or gas inclusions and with well distributed tin and lead content can be made."

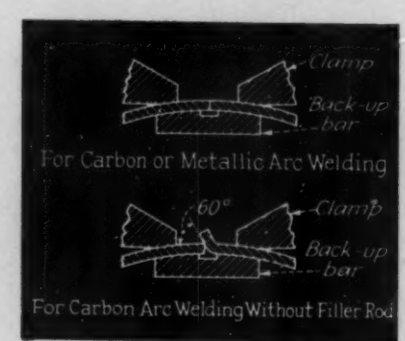
Oxy-acetylene welding of copper-silicon alloy sheets ¼ in. or less in thickness should be completed in one operation, concentrating the heat on as narrow an area as possible. A slightly oxidizing concentrated flame should be used. Although plates of any thickness can be welded with one bead, better welds may be made on material ¼ in. thick and over if multiple beads are used, thoroughly removing all slag and oxides, and refluxing, before proceeding with the next bead. If possible, incline the work about 30 deg.

ARC WELDING

Both the carbon arc and the metallic arc methods of electric welding find application in the joining of "bronze" alloys. Because of the high welding speed and uniformly good results obtained, the carbon arc method has become the process generally used for metals in this group.

Some difficulty is encountered in welding beryllium copper because of its film-forming oxides. However, with care good welds may be formed using beryllium copper or silicon copper filler rods with a carbon arc. When possible, the weld should be chilled rapidly. No flux is necessary, but current must be adjusted for rapid melting to insure successful welds. This alloy can be spot or butt welded without difficulty.

Back-up bars under the joint are desirable when carbon-arc welding copper-silicon alloys, but are not absolutely necessary. When more than one bead is to be laid, each bead should be lightly peened from both sides, wire brushed thoroughly to remove all scale and flakes of oxide, and again dusted lightly with flux before the second bead is applied. After the second bead heavier peening can be done, the object of this being to cold work the metal. Subsequent welding will anneal this cold worked metal and provide a certain amount of grain refinement. Such welds later can be annealed with an oxy-acetylene torch by heating to a dull red heat, about 1,200 F.



Copper-silicon sheets less than 1/4 in. thick can be butt welded without beveling the edges. A groove in the back-up bar allows the bottom edges to be fused without permitting an excess of metal to fall through

Metallic arc welding is satisfactory for thin gages in copper-silicon alloys, and has been used satisfactorily for welding some of the nickel silvers, the 30 per cent cupro-nickel alloy, and several of the nickel-aluminum bronzes. When using this process with a bare electrode, reversed polarity is used. As short an arc should be employed as can be maintained satisfactorily and still obtain complete fusion. If heavier plates are to be welded by this method, coated rod should be used. Straight downward welding and high welding speeds are recommended.

Both hard and soft copper-silicon sheets may be spot and seam welded easily. The setting of the welding machine for these materials is somewhat different than that used for steel. In general, the pressures should be lighter, the current slightly heavier and the time shorter.

Eyes Front

CONGRESS has gone home. But before it left Washington it performed a notable service to industry and the country.

It brought pump priming to an abrupt halt by rejecting the President's spend-lend program. It tightened the reins on W.P.A. expenditures. It passed a tax bill not unfriendly to business. It enacted the Hatch Bill to take politics out of relief. It voted an independent inquiry into the doings of the National Labor Relations Board.

It took political courage to do these things. And, like it or not, it puts industry in a spot where it must do more than twiddle its thumbs and wait for Congress next January to enact further measures pleasing to business.

For the truth is that Congress has taken a step in the direction long urged by industry, and now the public generally is inclined to expect industry to exert leadership in promoting recovery and employing more people. Even Republican leader Martin of the House puts the job of reemployment squarely up to industry.

Overshadowing all other problems—political, economic and social—is the task of trying to put nine to ten million idle men to work. Unemployment is still America's No. 1 problem.

Now there are two ways of employing the idle. Industry can absorb them, or the government can make work for them, as it has been doing on a grand scale. The preferable way is the first.

So the best thing industry can do is to bend all its energy toward promoting recovery and thus reemploying as many people as possible. Various trade indices suggest that there is plenty of business for the picking. Industry should not let politics or anything else divert its attention from the main task of doing the picking. Eyes should be front, not to the side.

You may say, "What do you think I have been doing all this time if not trying to put more men to work?" Certainly you have been, but unfortunately the man in the street doesn't always believe so. He has had dinned in his ears by the Leftists the fact that profits are the sole aim of business and the welfare of the country is secondary.

There is only one way of disproving that statement: by tackling the recovery problem vigorously and relentlessly and not by thinking up a dozen reasons why progress cannot be made under present conditions.

After all, the best industrial and public relations job that industry can do is to provide employment for just as many people as possible. If it succeeds between now and January in making any appreciable dent in the unemployment ranks, members of Congress will be given further cause to push along the middle road down which they started this year.

Burnham Finney

GAGING BUSINESS

Thanks to government orders and to a booming export trade, metal-working plants are in the midst of an active summer. Japan is a big customer. Aircraft and shipbuilding are hot spots.

Stimulated by government defense orders and by foreign contracts in connection with armament programs, the metal-working industry is in the midst of an exceedingly active summer. No let-up in operations is looked for. In fact, output is more likely to increase rather than decrease. The importance of exports is shown by the fact that shipments abroad of metal-working machinery in the first half of 1939 jumped to $55,685,450, a new high. Of that amount Japan as the leading customer took $13,237,230.

AIRCRAFT—War Department contracts for $100,000,000 are booming plane production. Glenn L. Martin got orders for $15,815,000 and North American Aviation for $11,771,000 of two-engined bombardment planes. Consolidated Aircraft and Boeing will supply four-engined bombers valued at $8,485,000 and $8,090,000 respectively. Other army plane awards are: $4,845,000 to Lockheed for twin-engine interceptor pursuit units; $4,033,000 to North American Aviation, $2,986,000 to Vultee and $688,000 to Stearman for training planes. Aircraft engine orders went to United Aircraft for $12,320,000, Wright Aeronautical for $7,000,000, Allison Engine for $2,275,000, and Lycoming Division of Aviation Corp. for $270,000. Backlogs of Pacific Coast plane factories have risen spectacularly to $115,000,000.

FARM IMPLEMENTS—Low prices for farm products have so slowed implement buying that sales this year may not reach the '38 figure. International Harvester's volume of business is understood to have been retarded by extensive retooling and redesigning programs which culminated recently in announcements of three new tractors and accompanying implements. J. I. Case is reported considering entering the low-price tractor field either the latter part of this year or wait until next spring.

STEEL—At the year's peak of better than 60 per cent, mill operations currently are running ahead of consumption. Early releases from automobile companies, however, should correct the situation. Miscellaneous users are taking an unexpectedly large volume. Government purchases will be an important factor in steel tonnage the remainder of this year.

FOUNDRY EQUIPMENT—Incoming business was less in July than in the previous month, but was 50 per cent better than in July, 1938. Unfilled orders have declined somewhat.

GEARS—July sales were only slightly under June's and were 34 per cent ahead of those in the same month last year, reports the American Gear Manufacturers Association.

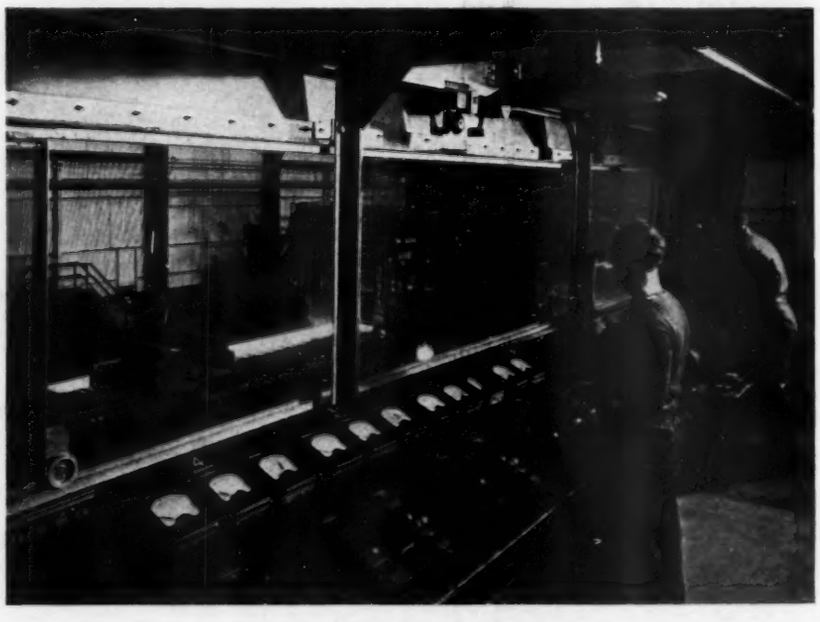
RALROAD EQUIPMENT—Freight car and locomotive orders have been well above those a year ago, but considerably under the '37 total. The outlook is only fair at best. I.C.C. has granted permission to fabricate tank cars by fusion welding, 50 by General American Transportation Corp. for handling caustic soda and 10 by American Car & Foundry for petroleum. Chicago & Northwestern has asked for bids on 800 freight cars. Electro-Motive Corp. is busy on diesel electric locomotives.

SHIPBUILDING—Indicative of the revival in shipbuilding is the fact that 62,000 men are now employed in navy yards and 50,000 in private yards mostly on navy work. This is an all-time high. The Maritime Commission has awarded five combination cargo and passenger ships to Federal Shipbuilding at $1,909,000 each. The Consolidated Steel Corp., Long Beach, Calif., is reported in line for four ships to be built for the Maritime Commission.

AUTOMOBILES—Assemblies of '40 models will increase gradually until they hit a fall peak in October. Pushing ahead the annual shows to October is expected to aid fall retail sales tremendously. Parts factories thus far have not received releases in appreciable volume.

ELECTRIC APPLIANCES—Refrigerator and washing machine output and sales have been far above the year's expectations. Trend in refrigerators is toward more efficient mechanisms and larger boxes.

Steel Top—*Steel operations have hit a new high for 1939. Output, now above 60 per cent, is expected to continue close to current levels for the remainder of the year. Automotive tonnage soon will increase sheet mill rollings*



NEWS OF THE INDUSTRY

NIGHT DRIVING STRAIN RELIEVED BY "SEALED-BEAM" HEADLAMPS

DETROIT—"Sealed beam headlamps" are to be standard equipment on all 1940 models except the Willys. Their introduction marks the successful termination of a three-year program by the automobile and headlamp industries to make night driving safer. For the first time the reflector, light source and lens are made into a single permanently sealed unit about 7 in. in diameter. This unit is replaceable at a cost of $1.25–$1.50 each. One-third more light, twice the life of a present 32-cp. bulb, and a permanently clean and efficient reflector are advantages of the sealed-beam construction. The light will be more widespread but without glare in the eyes of an oncoming driver. It will illuminate the entire road and permit the motorist to see farther, quicker and better.

The lighting unit is not suitable for installation in 1939 and earlier cars. Procedure for replacing a unit is comparatively simple. Vertical and lateral adjustment must still be made as in the case of previous headlamp constructions. However, the amount and placement of light are now strictly controlled.

These sealed-beam units are being made by General Electric, Guide Lamp and Hall Lamp. They are interchangeable on all cars. Control on all cars is standardized. A two-position switch will be mounted on the dash—one position to turn on the headlamps and the other to control the parking lights. The latter are separate from the headlamps, and are often worked into the engine-hood design so that they can be seen from all angles. But the sealed-beam headlights have a traffic beam and a country beam selected by a foot switch. A red warning light on the dash will glow while the country beam is in use.

MACHINE TOOL INDEX SOARS AGAIN

CLEVELAND—The index of machine tool orders, compiled monthly by the National Machine Tool Builders Association, climbed 19 points to reach 230.9 for July, 141 points above the figure for July, 1938, and the highest since April 1937. The three months average advanced to 220.8, marking the first time since the middle of 1937 that it has topped the 200 mark.

While sustained foreign demand accounted for about half the total volume, gradual improvement in the distribution of orders throughout the industry indicates a broadening domestic demand, the association noted.

SHIP CONSTRUCTION BOOMING; PROGRAM'S SUCCESS ASSURED

By Blaine Stubblefield

WASHINGTON—The outlook for success of the Maritime Commission's ship replacement program is now better than ever since enactment of the construction subsidy in 1936. American flag foreign services, who alone are affected by the Act, for many months were reluctant to assume heavy new capital obligations, even under the Government's generous down payment and 20-year loan terms. But now, with maritime labor troubles quieted and world traffic booming, several lines are contracting for new tonnage under purchase, lease, or charter agreements. The Commission's total construction program now covers 66 ships.

In the regular independent offices appropriation, Congress voted the Commission $100,000,000 in cash for 1940, plus $230,000,000 in contract authority in addition to the $115,000,000 contractual power contained in the original Act. With a total backing of about $445,000,000 for all purposes of the law, the Commission faces no financial restrictions.

Next few weeks will show what interest will be taken among shipping companies in the Government's offer to accept trade-in of obsolete vessels for credit on new equipment. The Commission is already receiving some inquiries and is hurrying preparation of application blanks. Its rules of procedure have already been published. The trade-in scheme, authorized in the new Bland amendment and generally regarded as a subsidy in false whiskers, applies to all ships of American registry.

Thus well healed and with improved cooperation of the industry, the Commission expects to go ahead averaging 50 ships a year for ten years. Of course the question whether the industry can absorb such huge new capital costs will not be clearly answered for some time to come. While American foreign-service has the advantage of subsidy, both for construction and operation, nearly every one of its competitors has the same advantages. It really amounts to an international subsidy race, with this country's prospects brightening as other governments sail closer to bankruptcy.

U. S. Maritime Commission's Foreign-Service Ship Replacement Subsidy Program

Vessels under construction and contract as of July 31, 1939

Builder	Operator	Number	Propulsion	Percentage Completion
Bethlehem Steel Co., Shipbuilding Div., Fore River Yard	American Export Lines	4	Turbine	80, 65, 39, 35
Sparrows Point Yard	Miss. Shipping Co.	3	Turbine	22, 14, 2
Sparrows Point Yard	Standard Oil Co. of N. J.	3	Turbine	75, 62, 14
Federal Shipbuilding & Dry Dock Co.	American Hampton Roads-Yankee Line	4	Turbine	100*, 97*, 90, 70
"	American Pioneer Line	2	Turbine	50, 47
"	Standard Oil Co. of N. J.	2	Turbine	99, 48
"	.....	6	Turbine	30, 22, 15, 15, 10, 8
Ingalls Shipbuilding Corp.	.....	4	Turbine	All 4
Moore Drydock Co.	.....	2	Turbine	32, 12
Newport News Shipbuilding & Dry Dock Co.	American Hampton Roads-Yankee Line	2	Turbine	91*, 84*
"	Grace Line	2	Turbine	52, 44
"	Round-the-World Service	6	Turbine	All 1
"	Standard Oil Co. of N. J.	3	Turbine	58, 20, 12
"	United States Lines	1	Turbine	53
Sun Shipbuilding & Dry Dock Co.	Moore-McCormack Lines	6	Diesel	100*, 98*, 93, 78, 66
"	Seattle-Orient Line	4	Diesel	All 1
"	.....	4	Diesel	20, 20, 12, 12
Tampa Shipbuilding & Engineering Co.	American Pioneer Line	4	Diesel	38, 37, 7, 7

* Already launched.

INSIDE DETROIT

By Rupert Le Grand
DETROIT EDITOR

Automobile production slumps as Ford and Chevrolet labor over changeovers. Hudson takes advantage of the lull to spring its new models, with Packard and Willys hot on its heels.

DETROIT—Motor car output will not start a real climb toward the fall production peak until Chevrolet and Ford resume assemblies. Ford went down Aug. 11 on its main assembly operations and is not expected to become active again until after Labor Day. Its tool and die program is on time. Chevrolet finished '39 assemblies the middle of July and will not get going again much before Oct. 2. This means that its assembly lines will be idle for eleven weeks compared with six weeks normally.

Other General Motors divisions are not so badly off as Chevrolet. Buick and Pontiac are reported making cars. Cadillac may turn out 100 jobs next week but will probably not increase the tempo for another month.

Chrysler divisions are relatively in the best position of all the Big Three producers. Plymouth is said to have begun assemblies Aug. 14, but DeSoto probably will not make any headway before next week. Hudson so far is the only independent maker which has maneuvered itself into position to capitalize on a brisk market occasioned by an earlier than anticipated sell-out of 1939 models, a good clean-up of used cars, and inability of several producers to make a quick model changeover.

Chevrolet Hit Worst

Worst hit by an unusual combination of circumstances is Chevrolet. At first it scheduled final 1939 assemblies for about Aug. 1. But material had been ordered on the basis of 50,000 cars in June and 50,000 more in July. Sales soared in June and July far above original estimates, and available material ran out the middle of July. Almost 35,000 more cars could have been sold than were produced.

To make the situation more uncomfortable, the tooling up program was held up for over four weeks by the strike. Much of the time lost, however, is being made up. The original plan was to start 1940 assemblies Sept. 18, but they will of necessity be deferred another two weeks until Oct. 2. Even so, it is not expected that more than 10,000 units can be produced by show time (Oct. 15), and that number is only one-third of the quantity needed to stock dealers. Of course, Chevrolet now has all primary production plants in operation.

Ford's new tool and die shop has justified itself on the first new-model program to be put through it. The savings in labor and time are reported to be 25–30 per cent. Not only is the shop equipped with the latest Keller die sinkers and Southwark hydraulic spotting presses, but exceptionally complete materials-handling equipment and power tools assist in cutting time on a front fender die, for example, to four weeks.

Hudson Takes the Lead

Newspapermen were caught off guard on Aug. 9 when Hudson announced at its press preview that its factory was working full tilt, and that its new cars were then on the market. Thus Hudson was the first motor car manufacturer to start the 1940 selling season, evidently with the intention of making hay while General Motors, for one, was embarrassed about the length of time required for model change-over.

Consensus of opinion is that Hudson's three new lines of cars have distinctive body treatment with good sales possibilities, and that the chassis details now follow conventional practice. The entire automobile is a well balanced creation, without straining for mechanical oddities or excessive value.

The 113-in. wheelbase Hudson Six Deluxe will be competitive with the deluxe Ford, Chevrolet and Plymouth. It develops 92 hp. as compared with 86 previously. Economy is improved by 1½ miles per gallon. A stripped job for fleet use will be known as the Six.

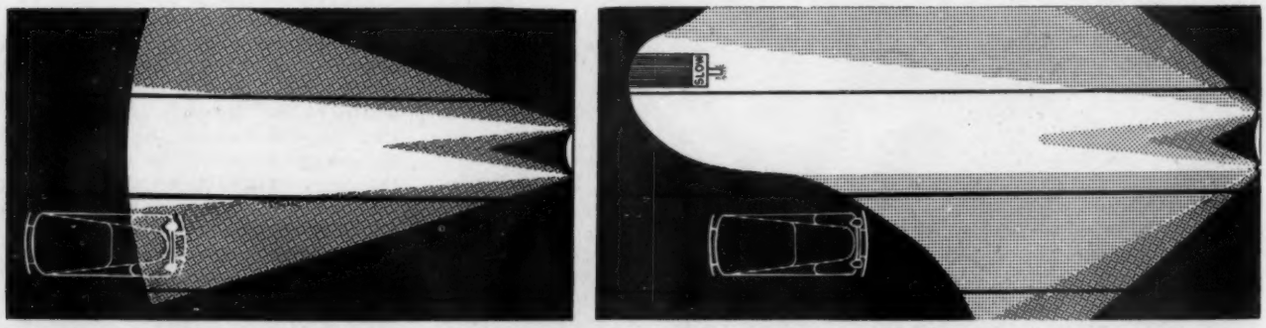
The Hudson Eight is a new model, having a 128-hp. straight-eight engine in a 118-in. wheelbase chassis. Companion car is the Super Six with a 102-hp. engine in the same chassis.

Two 125-in. wheelbase models are the Country Club Six and Eight. These are powered respectively with 102 and 128 hp. engines. All cars in the line offer substantially greater horsepower and economy.

Independent Suspension Adopted

For the first time Hudson uses independent coil-spring wishbone-type suspension on the front wheels. The design is identical for all models and is composed of conventional stampings and forgings. A Monroe-type shock absorber is mounted within the coil spring, because this location has advantages with respect to shock-absorber action. An improved "Auto-Poise" control consists of a torsion bar connected to the front wheels by means of levers set at an angle. It is said that these levers always apply correctional influences to independently sprung wheels in making turns and in case of a blowout. The control is said to resist any force that tends to deflect the front wheels from a straight course.

Handling is improved by a center-point steering mechanism that has only been used previously on more



"Sealed Beam"—*Traffic beams typical of majority of cars, left, poorly light right side of road. "Sealed-beam" lamps, of greater precision and higher efficiency, throw light where it's needed most.* (*Description on page 654c*)

expensive competitive makes. Rear springs are now 60 in. long in order to give a softer ride.

Luxurious Interiors Featured

Great emphasis is laid by Hudson on interior appointments of its new models. Airfoam seat cushions are continued, but are redesigned for greater comfort. They are optional on the lowest priced Six and Six Deluxe, and standard on all other models. Seats are massive and deep formed. All upholstery fabrics are of fine quality but a new high is achieved in the material used in the Country Club series. A rich wool tweed, said to be as fine as any ever used in standard cars regardless of price, will be employed. Chromium-plated moldings are lavishly used over the two-tone door upholstery and achieve a distinctly custom effect. Interior dimensions of the larger cars would be such as to create an impression of great roominess if ordinary upholstery were specified. But with deep pillowy seats and huge arm rests, the visible space appears considerably reduced. Even so, five or six persons can doubtless ride comfortably.

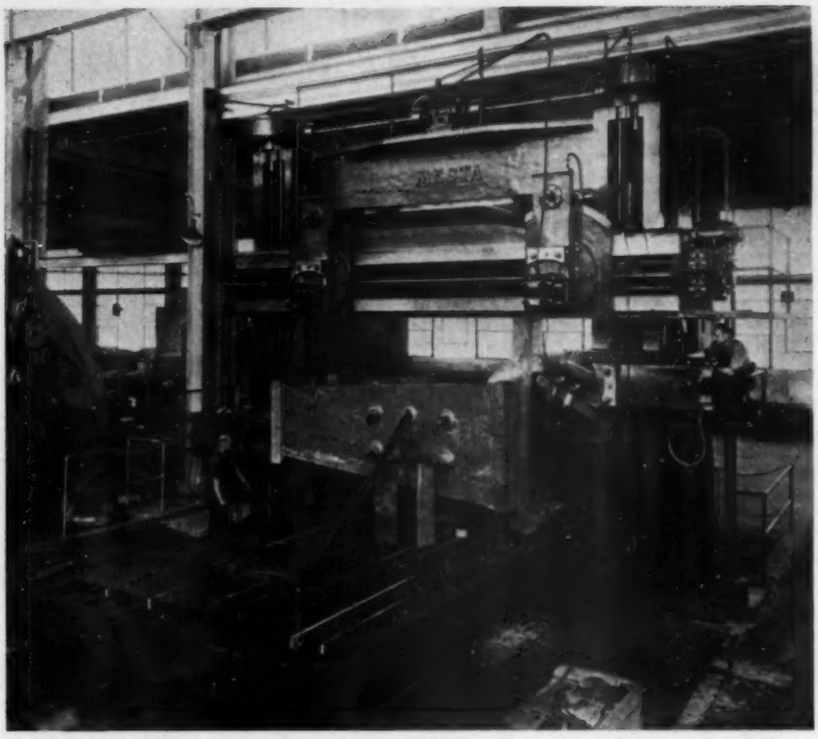
Packard's One Sixty

Packard did not depart from its well known styling in any of its four lines, and did not bring out the new small job which has been in the offing for many months. The 1940 line consists of the One-Ten (a six) and three eight-cylinder models—the One Twenty, the One Sixty and the One Eighty. Packard no longer builds a twelve.

The One Sixty is powered by a 160-h.p. engine, which is the previous Super Eight engine stepped up to give exceptionally brilliant performance in a 127-in. wheelbase chassis.

The most significant change is a series of price reductions. Compared with a year ago, the price of the One Ten is down as much as $120, and of the One Twenty about $120. But compared with the lower prices established last spring these cuts amount to only $20 and $50 on the two models.

Chassis refinements are found mainly in the front suspension members and entail larger bearing surfaces, larger and more effective dirt seals, and more lubrication points. The overdrive has been improved so that it cuts in at lower speed and without a heavy click. A governor connected to the overdrive lights a dash light when the mechanism is properly synchronized. Hydraulic valves make for quieter engine performance. Carburetion is improved. Seats have Airfoam cushions. Bodies appear to be the same as last year. Door catches are of die-cast construction. The radiator shell has been narrowed, and the traditional Packard lines are strongly retained. Packard is striving to produce 8,500 to 9,500 cars in August.



Giant Planer—*Installed by Erie Foundry Co., Erie, Pa., this mammoth planer machines huge steam hammer parts. It weighs nearly 450 tons, is driven by a 75-hp. motor, and can take castings over 16 ft. wide and 14 ft. high. Table speed can be varied from 3.2 to 96 ft. per min. in both directions*

Willys Gets New Start

Under the guiding hand of its new president, J. W. Frazer, Willys-Overland has paid off its bank loans, is qualifying for a $2,500,000 RFC loan to improve its working capital, and has produced a fresh design for 1940 without going to much expense. The body of the deluxe and standard sedan types remains the same, but the overall length of the car is increased 2 ft. Skillful revamping of the hood, particularly to get rid of the bulbous effect on the front, puts Willys into close relationship in body styling with other and larger new models previewed so far. For the first time in recent years the car looks like a quality job, and it will carry a lower price tag. New this year is a coupe model which should attract attention of traveling men and the younger set.

Mechanical changes have been limited on the Willys to better carburetion, a counterweighted crankshaft, bigger bearings, ability to turn up to 5,000 r.p.m. with safety, a reduction of 50 lb. in weight, and increase of front and rear leaf-spring dimensions until their combined length now equals 78 per cent of the wheelbase, which is unchanged. Leaf springs are rolled in a new parabolic section, which is said to permit more stress on a thin leaf, which in turn gives a softer ride.

Willys' dealer position has improved steadily, and the company has scheduled 4,000 assemblies for September.

Nash Holds Off

Nash assembled approximately 1,100 of its new models last week, but is not expected to show them to the public until about Sept. 8 or 9. At a press preview on Aug. 10, it was evident that earlier predictions concerning few body or mechanical changes were entirely true. The catwalk is now at practically right angles with the face of the cooling grilles or louvres. Other slight modifications in the front end enhance the appearance of the car's being on tiptoe ready to dash off at the driver's will. There is possibly a greater sweep on the rear deck. Interior appointments include a new "canda" cloth upholstery which has a lot of cotton in it, can't be told from mohair if one wants mohair, and on the other hand feels and looks like broadcloth if one wishes that fabric. In other words, the salesman can satisfy all comers with one material.

Nash had such good sales in the early summer that it too was cleaned out early, and is understood to be in the unfortunate position of not being able to move quickly enough to overcome the difficulty.

WATCHING WASHINGTON

McGraw-Hill Washington Bureau

PAUL WOOTON, CHIEF

Denial of Army's request to change bidding for plane orders is major snag hit by defense program. Japanese trade treaty abrogation gives embargo power to President and Congress.

WASHINGTON—Army's failure to get from Congress authority to negotiate airplane procurement outside the bidding system was the only major upset in the defense program which otherwise went through like an express plane downwind. Curbstone talk was that the Administration couldn't support the Army strongly because it cracked down on Maj. Gen. Benjamin D. Foulois when he was chief of the Air Corps for playing outside the framework of bidding. Other chiefs had done it before him. The administration was accused of attacking Foulois as a face saver after the Farley-Roosevelt cancellation of air mail contracts and the Army's tragic failure to fly it. Army's second choice, which was authority to accept second and third bidders as a means of hurrying toward the 5,500-plane objective by June 30, 1941, was also turned down by Congress, apparently for two reasons. One, the law makers pigeonholed it and skipped the Potomac heat wave; two, they found that the War Department already is authorized to accept second and third bids by the air corps law of 1926. Though it doesn't give full leeway, the Army is invoking that law to the limit. Multiple bidding will augment production, but it will not help small concerns into the military field. They need backing to develop designs; Army could have furnished it by negotiation.

More Pump Priming?

President Roosevelt's contention that defeat of his lend-spend and his big housing bills will have an adverse effect on business is questioned by a majority of observers here. The Capital hears that business leaders are cheered almost to a man by the act of Congress in "taking over its constitutional rights." Opion is that if the business index drops, the administration will say "I told you so" and put on the steam next session for more spending. Some think that no matter how bright the business horizon, FDR will still try the pump.

Ability First

There is no political angle on appointment of four big business men and two academicians as an advisory War Resources Board to the Army-Navy Munitions Board. The President and the Services were looking for top grade ability. The Munitions Board has recently been made responsible directly to the President instead of to the Secretaries of the Army and the Navy. In an emergency the War Resources Board would become an executive agency of the Government, and Edward R. Stettinius, Jr., its chairman, undoubtedly would be dictator of American industry.

Loophole in Plane Exports

Refusal of Congress to repeal the embargo on arms to warring nations would seem to preclude the export of airplanes if Europe fights. This country's foreign sale of aircraft is now in the class of major industries. One of the mainsprings of pressure for repeal of the embargo was fear of damage to our foreign trade in aeronautic equipment. But if war comes while the embargo is still on, it is possible that the President, under the law, could take airplanes out of the munitions list and put them in the "other commodities" list, regarding which the cash-and-carry provisions expired May 1.

WANING INFLUENCE

The Department of Commerce is expected to remain a mere high-stool statistical agency, with little or no voice in the national policy, despite Secretary Hopkins' appointment of his brain crew to harmonize administration reforms with business. You probably will hear no more of these people than you have heard of Under-secretary Edward J. Noble, who bailed out of the Civil Aeronautics Authority to prove that general industry could be boomed like aviation. Mr. Hopkins' new experts are not the type he was looking for. Men of the Stettinius stripe will hook onto an advisory board for war emergency in which all of the people will be of one mind, but they won't crawl out on a limb with the bitter presidential battle just around the corner.

Andrews to Crack Down

For a long time Wage-Hour Administrator Andrews talked so softly that the Capital wasn't sure whether he would be a tough guy or a benevolent judge in a show down. It knows now that he carries "knucks" in his velvet glove. Oct. 24, first birthday of the statutory minimum wage section of the law, and day of the automatic step-up from 25 cents to 30 cents with reduction of hours from 44 to 42, will find Andrews with $1,200,000 "compliance" money voted by Congress, and a long start on his plan to set up sixteen regional enforcement offices. Andrews figures that violators must be brought to their knees now or never. He lost some prestige when he "crawfished" under labor pressure on his proposed exemption of salaried workers from the hours provision.

Future for Flying Windmills

Watch rotary-winged aircraft from now on. High authorities on design have never been convinced we have the final form in the fixed wing, and they are increasingly fascinated by the whirling blades as helicopters are brought closer to efficiency and required speeds. Many firmly believe that the fixed wing will never create a sizable private plane industry and that the windmills will. Air Corps has $300,000 to spend on rotor research at Wright Field. Incidentally the State Department is a bit miffed with Kellett for selling an autogiro to Japan against Hull's moral edict against export of planes to the Japanese.

Exporters on the Spot

Six months' notice by the State Department of intention to abrogate the 1911 commerce and navigation treaty with Japan puts exporters of metal-working machinery to that country up against a problem. Termination of the treaty would not mean that trade with Japan must stop. It means only that the President and Congress will have a free hand to put on new tariffs or embargo on certain goods as they see fit. The problem of exporters is the making of commitments or production plans which might be impossible to carry out in the future. This country sold to Japan in the first half of this year $14,700,000 worth of metal-working equipment, roughly 30 per cent of the total exported.

No Cash for Canal

There is no appropriation for new locks at Panama authorized at a cost of $277,000,000. The Canal Zone has on hand sufficient funds to draw plans and make ground tests, but construction money will be appropriated by the next session of Congress.

PERSONALS

W. J. ADAMS, formerly with the Continental Roll & Foundry Co., East Chicago, Ind., has been added to the engineering staff of Gar Wood Industries Inc., Detroit, Mich., following the recent acquisition of Continental's tractor equipment division by Gar Wood.

NEWTON P. ARMSTRONG has been appointed New England district representative, Cowles Detergent Co., Cleveland, Ohio, with headquarters in Boston. FREDERICK M. HITCHCOCK has been appointed Michigan representative, with headquarters in Detroit.

JOHN A. BAUER, for the past several years in charge of the New York office Hanson-Van Winkle-Munning Co., Matawan, N. J., has been transferred to the company's home office to assist L. M. HAGUE, vice-president in charge of sales. CHARLES L. ANGER has joined the organization's sales staff.

I. J. BOOTH, formerly in charge of the aluminum department of Pacific Metals Co., Los Angeles, Calif., has been appointed vice-president in charge of sales, Harvill Aircraft Die Casting Co., also of Los Angeles.

F. W. BOYE, III, has been elected vice-president of the Boye & Emmes Machine Tool Co., Cincinnati, Ohio.

HENRY W. BURRITT, former vice-president in charge of sales Kelvinator division, Nash-Kelvinator Corp., has been named president and general manager of the Eureka Vacuum Cleaner Co., Detroit, Mich. He succeeds FRED WARDELL, founder, who has been elected chairman.

FREDERICK M. GILLIES has been appointed general superintendent of the Indiana Harbor work of the Inland Steel Co. He succeeds HENRY R. DEHOLL, retired.

CARL C. JOYS, JR., has resigned as vice-president and sales director of the A. O. Smith Corp., Milwaukee, Wis.

IRA C. KELLER has been elected a vice-president of Container Corp. of America, Chicago, Ill.

PAUL S. MENOUGH, formerly with the Duraloy Co., Michigan Steel Casting Co. and Michiana Products Co., has been named chief engineer at the Cleveland, Ohio, plant of the Standard Alloy Co. FRANK P. MORROW, former Detroit district manager, has been appointed sales manager.

MANLEY E. LORD

MANLEY E. LORD, since 1935 co-ordinator of all refrigerator manufacture for the General Electric Co., Schenectady, N. Y., has been named assistant to W. R. BURROWS, vice-president in charge of manufacturing. He will be succeeded by JOSEPH F. ECKEL.

Mr. Lord first joined General Electric in 1908 while still a student in Newark Technical School. He worked up to the position of assistant superintendent in charge of production at the Newark incandescent lamp factory, and in 1917 went to the Edison Lamp Works at Harrison, N. J., in charge of general production. In 1928 he was transferred to Schenectady, and two years later he joined Mr. Burrows' staff, serving as secretary of manufacturing committee. In 1935 he became co-ordinator of refrigerator manufacturing.

WILLIAM H. JEWELL, for the past 23 years associated with the Ingersoll-Rand Co., has been appointed general manager of its Athens, Pa., plant. He succeeds JOHN M. FELT, resigned.

CLARENCE REESE has been elected president of Continental Motors, Detroit, Mich. He succeeds W. R. ANGELL, who has resigned as president, treasurer and director.

EDWARD B. TAYLOR, for the past 21 years employment manager of the Wickwire Spencer Steel Co., Palmer, Mass., retired from service July 29 at the age of 80.

TOM TURNER, who joined Westinghouse Electric & Mfg. Co. in 1922 as a machinist, has been appointed manager of the company's meter division in Newark, N. J. He succeeds RALPH M. RUMBEL, deceased.

J. H. VOGEL, formerly assistant works manager in charge of methods and equipment, York Ice Machinery Corp., York, Pa., has been appointed general works manager.

R. S. NEBLETT has been appointed assistant manager of the turbine division, General Electric Co., Schenectady, N. Y.

F. A. WRIGHT has been appointed manager of resale sales, Cutler-Hammer Inc., Milwaukee, Wis. He succeeds B. M. HORTER, who was recently named general sales manager.

BUSINESS ITEMS

Atlas Press Co., Kalamazoo, Mich., has increased its production capacity by a plant addition providing 17,000 sq. ft. more working area.

Boeing Aircraft Co. of Canada, Ltd., is planning a $300,000 aircraft factory at Vancouver, B. C.

Bendix Aviation Corp. of California is building new factory and office structures at Union Air Terminal, Burbank, Calif., at a cost of $40,000.

C. F. Braun Co., Los Angeles, Calif., is erecting an addition to its shop and foundry at a cost of $33,000.

Curtiss Aeroplane Div., Curtiss-Wright Corp., Buffalo, N. Y., has closed its plant to make readjustments for handling increased production. Soon after the plant is reopened, work will be started on some 400 pursuit ships to be built for the Air Corps.

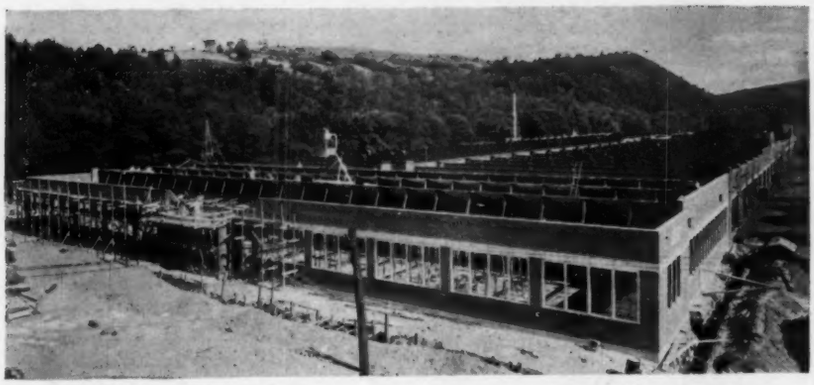
Hanson-Van Winkle-Munning Co., Matawan, N. J., has appointed Carl F. Miller Co., Seattle, Wash., as Washington distributor for its electroplating equipment and supplies.

Inland Steel Co., Chicago, Ill., has licensed the American Rolling Mill Co., Middleton, Ohio, and the Heppenstall Co., Pittsburgh, Pa., to manufacture its "Ledloy" free-machining steel.

Jackson Iron Works, Inc., Vernon, Calif., is constructing three new plant buildings in South Gate, Calif., adding 16,000 sq.ft. to its manufacturing space.

Martin & Schwartz, Inc., Buffalo, N. Y., manufacturer of oil and gasoline pumps, is planning to move its manufacturing operations down South.

White Aircraft Corp., LeRoy, N. Y., has purchased the design, patterns, dies and manufacturing rights for the Verville training plane from Alfred V. Verville of Washington, D. C. The Verville ship was manufactured several years ago in Detroit.



Diversification—*More space is needed in the Springfield, Vt., plant of the Jones & Lamson Machine Co. since it added thread grinders and larger turret lathes to its line. 240x100-ft. addition provides 2,500 sq.ft. of shop space, frees still more space in older structure for shop operations*

OBITUARIES

FRED W. COOMBS, 69, who joined the Gisholt Machine Co., Madison, Wis., in 1895 as a bookkeeper and advanced to vice-president, died July 29 in Orlando, Fla. He had been inactive in company affairs since 1937 because of failing health.

LEO O'CONNOR, a foreman at the Harley-Davidson Motorcycle Co., Milwaukee, Wis., died Aug. 7. He was 54 years of age.

JAMES T. PATTERSON, president and treasurer, Cornwall & Patterson Corp., Bridgeport, Conn., hardware manufacturer, died Aug. 6 in Milford, Conn. He was 58 years of age.

CHARLES RYSTROM, a founder of the Sundstrand Machine Tool Co., Rockford, Ill., died Aug. 5 in a hospital in that city at the age of 81. He became president of Sundstrand in 1910, and retired in 1929.

WILLIAM F. SCHULTHEISS, 67, president and founder Public Service Brass Corp., Los Angeles, Calif., died recently at his home in San Marino, Calif.

GEORGE F. SHIRLEY, sales representative O. S. Walker Co., Worcester, Mass., died July 30.

WILLIAM C. WHITCOMB, retired president of the Whitcomb Locomotive Mfg. Co., Rochelle, Ill., died Aug. 6 in Eagle River, Wis. He was 71 years of age.

MEETINGS

AMERICAN GEAR MANUFACTURERS ASSOCIATION. Twenty-second semi-annual meeting, Whitcomb Sulphur Springs, St. Joseph, Mich., Oct. 16–18.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Joint meeting with the Institute of Mechanical Engineers of Great Britain, New York, N. Y., Sept. 4–8.

AMERICAN SOCIETY FOR METALS. Twenty-first annual meeting, Stevens Hotel, Chicago, Ill., Oct. 23–28.

AMERICAN SOCIETY OF TOOL ENGINEERS. Semi-annual meeting, Hotel Statler, Cleveland, Ohio, Oct. 5–6.

AMERICAN WELDING SOCIETY. Twentieth annual meeting, Stevens Hotel, Chicago, Ill., Oct. 23–28.

ASSOCIATION OF IRON AND STEEL ENGINEERS. Thirty-fifth annual convention and iron and steel exposition, Wm. Penn Hotel, Pittsburgh, Pa., Sept. 26–29.

MACHINE TOOL SHOW AND CONGRESS, sponsored by the National Machine Tool Builders Association, Public Auditorium, Cleveland, Ohio, Oct. 4–13.

NATIONAL INDUSTRIAL ADVERTISERS ASSOCIATION. 1939 conference, Hotel New Yorker, New York, N. Y., Sept. 20–22.

PACKAGING INSTITUTE. First annual meeting, Edgewater Beach Hotel, Chicago, Ill., Oct. 12–13.

PORCELAIN ENAMEL INSTITUTE. Fourth annual forum, Ohio State University, Columbus, Ohio, Oct. 18–20.

SILVER BAY INDUSTRIAL CONFERENCE. Annual meeting, Silver Bay, Lake George, N. Y., Aug. 30–Sept. 2.

SOCIETY OF AUTOMOTIVE ENGINEERS. National aircraft production meeting, Hotel Biltmore, Los Angeles, Calif., Oct. 5–7. Annual dinner, Hotel Pennsylvania, New York, N. Y. Oct. 16.

U. S. Government Contracts Awarded to Metal-Working Firms

(Last-minute awards on page 654b)

Contractor	Gov't Agency	Commodity	Amount
National Tube Co., Pittsburgh, Pa.	War; Interior	Forgings; pipe	$118,489
Blaw-Knox Co., Pittsburgh, Pa.	T.V.A.	Steel towers	158,095
Aluminum Co. of America, Pittsburgh, Pa.	T.V.A.; War	Conductors; shapes	114,744
Phelps Dodge Copper Products Corp., New York, N. Y.	Navy, S. & A.	Tubes; pipe	136,980
Scovill Mfg. Co., Waterbury, Conn.	Treasury	Nickel blanks	51,500
American Brass Co., Waterbury, Conn.	Navy, S. & A.	Alloy tubing	129,969
Bart Laboratories, Bellville, N. J.	War, Engineer	Searchlight equipment	96,600
Commercial Engineering Co., Washington, D. C.	Navy, S. & A.	Compressor sets	85,547
Caterpillar Tractor Co., Peoria, Ill.	War; T.V.A.	Tractors	109,632
Wm. Sellers & Co., Philadelphia, Pa.	Navy, S. & A.	Machine tools	323,600
Brown & Sharpe Mfg. Co., Providence, R. I.	War, Ordnance	Milling machines	11,025
Gisholt Machine Co., Madison, Wis.	Navy, S. & A.	Turret lathes	25,963
Springfield Machine Tool Co., Springfield, Ohio	Navy, S. & A.	Engine lathes	12,369
Warner & Swasey Co., Cleveland, Ohio.	Navy, S. & A.	Turret lathes	11,252
Acme Machine Tool Co., Cincinnati, Ohio.	Navy, S. & A.	Turret lathes	12,165
American Tool Works Co., Cincinnati, Ohio.	Navy, S. & A.	Engine lathe	15,712
Giddings & Lewis Machine Co., Fond du Lac, Wis.	War, Ordnance	Boring mills	32,138
M. L. Bayard & Co., Philadelphia, Pa.	Navy, S. & A.	Hoisting machinery	180,170
General Electric Co., Schenectady, N. Y.	War, Engineer	Searchlights	1,230,240
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.	T.V.A.; Navy	Electrical apparatus	52,818
General Electric Co., Schenectady, N. Y.	T.V.A.; Navy	Electrical apparatus	211,711
United Aircraft Corp., Hamilton Standard Propellers Div., E. Hartford, Conn.	Navy	Propellers, tools	161,875
Keystone Steel & Wire Co., Peoria, Ill.	War, Engineer	Wire fabric	54,500
Mercer Tube & Mfg. Co., Sharon, Pa.	Navy, S. & A.	Pipe	73,663
Central Iron & Steel Co., Harrisburg, Pa.	Navy, S. & A.	Steel plate	88,811
Apollo Steel Co., Apollo, Pa.	Navy, S. & A.	Sheet steel	108,475
Hardinge Brothers, Inc., Elmira, N. Y.	War, Ordnance	Bench lathes	40,929
Pratt & Whitney Div., Niles-Bement-Pond Co., Hartford, Conn.	War, Ordnance	Machine tools	50,077
Monarch Machine Tool Co., Sidney, Ohio.	Navy, S. & A.	Engine lathes	12,313
Cincinnati Milling Machine & Cincinnati Grinders, Inc., Cincinnati, Ohio.	Navy, S. & A.	Milling machines	20,972
Warren Steam Pump Co., New York, N. Y.	Navy, S. & A.	Condenser pumps	57,348
Midvale Co., Philadelphia, Pa.	Navy, S. & A.	Racks; pinions	90,000
Sperry Gyroscope Co., Brooklyn, N. Y.	War	Sound locators; searchlights	3,308,375
Federal Telegraph Co., Newark, N. J.	Civil Aero. Auth.	Radio equipment	543,259
Allis-Chalmers Mfg. Co., Milwaukee, Wis.	T.V.A.	Electrical apparatus	51,858
Link-Belt Co., Chicago, Ill.	Panama Canal	Towing machines	272,627
Wright Aeronautical Corp., Paterson, N. J.	Navy, S. & A.	Engines	307,379

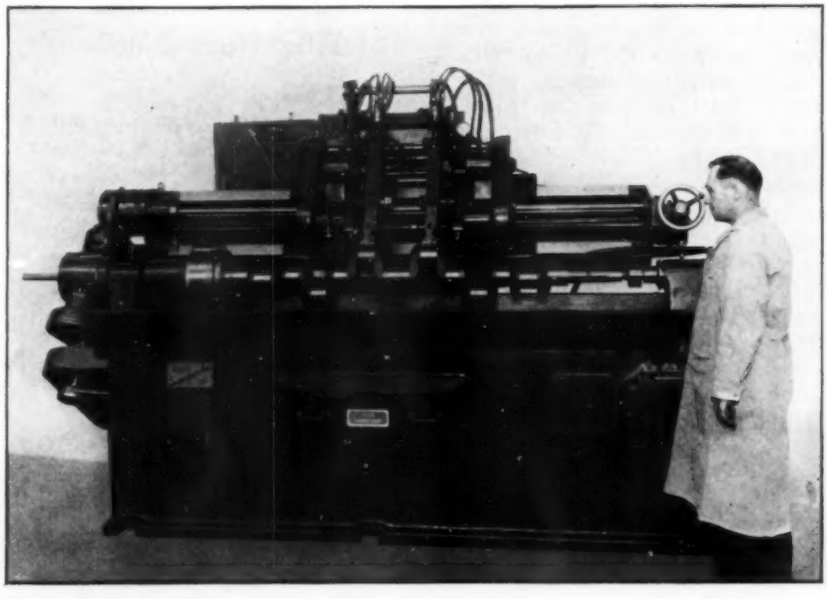
SHOP EQUIPMENT NEWS

Large Crankshaft Superfinisher Operates on Two Bearings Simultaneously

Developed for superfinishing pin bearings for diesel engine crankshafts, this "Universal" superfinisher developed by Foster Machine Co., Elkhart, Ind., has an adjustable headstock and tailstock, so that various lengths of shafts can be accommodated. The superfinishing heads, which operate on two pin bearings simultaneously, are adjustable to accommodate the throws of various crankshafts. This adjustment is made by a slide block arrangement for each head. Lateral adjustment also is provided for the head. Fluid motors are used for the oscillating movement of the head.

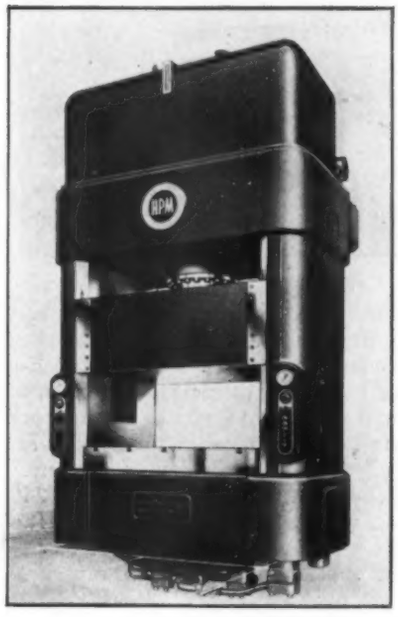
During the first twelve seconds of operation the work is revolved at approximately 40 r.p.m. for roughing; then there is a gradual increase of speed up to approximately 150 r.p.m. to give a lustre to the surface. The entire cycle is fully automatic and the motor is controlled by a dynamic control unit which, in turn, is hydraulically operated. A superfinished bearing of from 2 to 3 micro-inches is obtained on a production basis with this machine.

A similar machine also was built for superfinishing the main bearings of these crankshafts. It is arranged to take nine different crankshafts and the seven heads can be moved sideways, so that they will line up with the various main bearings on all of the crankshafts. Main bearings can be finished at the rate of from 1 to 2 min. per crankshaft, depending on size. Each of these machines weighs approximately 20,000 lb.



New 500-ton Press Has Double-Action

Developed especially for the sheet metal working industry, this "Fastraverse" double-action platen press announced by the Hydraulic Press Mfg. Co., Mt. Gilead, Ohio, has two separate hydraulic pressing members, the main slide and the die cushion located undernetah the bolster plate. The main slide is actuated by the double-acting piston-type ram working in a smooth-bored steel cylinder.

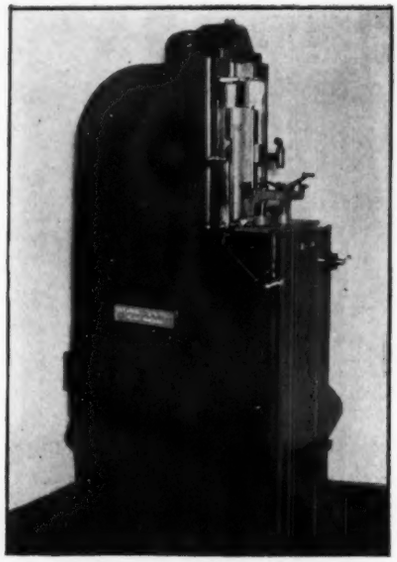


The radial pump is directly connected to this main cylinder, without operating valves. The main ram movement is controlled through regulation of the pump output which is both variable and reversible. Main slide has a pressing area of 72 x 60 in., while the die cushion slide has an area of 59 x 32 in. All piping, wiring and other equipment has been inclosed, but are easily accessible for adjustment or service. All gages and control stations have been flush-mounted into the press frame.

Broaching Unit Provides Simplicity of Loading

Developed primarily for broaching keyways in the taper holes of steering wheel hubs, a pull-down type of broaching machine developed by the Colonial Broach Co., Detroit, Mich., provides simplicity of loading and unloading, while eliminating both manual and automatic broach handling for internal broaching.

When the broach reaches the bottom of the stroke, the ram trips a release which allows the work holding cradle to move away from the broach. The work may then be removed and



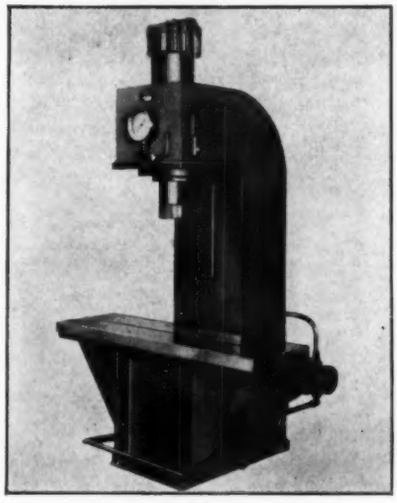
the cradle reloaded. The ram then returns to the top of the stroke, the work holding cradle is lowered manually, locating the part over a keyway horn which also serves as a guide for the broach, and then the broach is pulled down by hydraulic pressure. Standard stroke of the machine is 24 in., with a cutting speed of 30 ft. per min. and a return speed of 60 ft. per min. It is rated at 4 tons capacity.

"Transarc" Arc Welder Has High Efficiency

The Hobart Bros. Co., Box TA-69, Troy, Ohio, offers the "Transarc" a.c. arc welder for general welding in production and maintenance shops. Outstanding features claimed for this welder include safe operation, high efficiency, stable arc and low operating costs. The welder has a range of 20-200 amp. and is designed for use on 220 volt single-phase power line. Welding current is adjusted in a large number of steps, so that the current necessary for any job is available instantly. The unit is mounted on hard rubber casters and hand grips are provided on each side for lifting. The unit measures 32 in. high, 18 in. wide and 14½ in. deep. Weight is approximately 210 lb.

25-Ton Hydraulic Press Built for Straightening

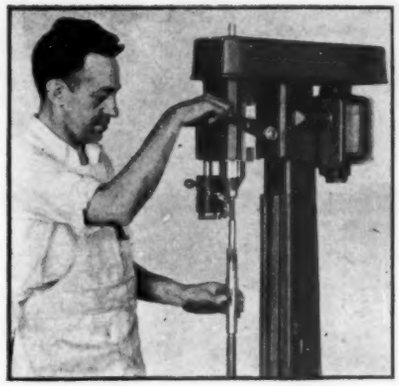
Similar in many respects to other presses built by the same organization, the 25-ton hydraulic press developed by the Denison Engineering Co., Chestnut and Water Sts., Columbus, Ohio, has been designed especially for straightening work, assembling and broaching.



The power unit mounted as an integral part of the fabricated steel frame consists of a 15-hp. motor with hydraulic pumps of proper sizes to effect a down speed of the ram of about 24 in. per min. Total stroke of the press is 18 in., and ram can be returned at approximately 48 in. per min. Length of the reversal stroke may be decreased by an adjustable stop, which also acts as an unloading valve control. Infinite tonnage variations up to the capacity of the unit may be obtained through a pedal.

Improved Center Lapper Offered by Ex-Cell-O

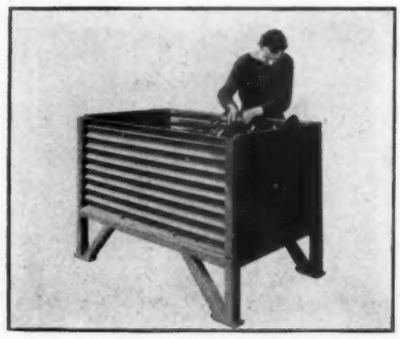
Female centers in parts held between centers and ground on the outside diameter can be lapped quickly on the improved center lapping machine offered by Ex-Cell-O Corp., 1228 Oakman Blvd., Detroit, Mich. Similar in principle to the previously announced lapper (*AM*—Vol. 82, page 849) this machine will lap centers up to $\frac{15}{16}$ in. in diameter, in work up to 10 in. in diameter and 36 in. long. With a special column, work up to 84 in. long can be lapped. Four-step pulleys, on the spindle and electric driving motor give lapping speeds of 700, 1,300, 2,500 and 4,650 r.p.m. The lapping stone dresser is so mounted that it can be swung in or out of position. The dresser diamond is passed at a 60 deg. angle across the stone by rack and pinion.



The part to be lapped is placed on a vertically adjustable work rest and held by hand while a lapping stone is brought down by hand lever. The work rest is prevented from dropping by a cam, and is locked in position by a hand crank. The spindle is connected by an arm to a counterweight in the column and is thus sensitive to lapping pressure.

All-Steel Container Fills Three Needs

The "Collapsi-Bin" all-steel work container offered by Mechanical Handling Systems, Inc., 4700 Nancy Ave., Detroit, Mich., has been designed to serve as a bin, rack, and



pallet. Of heavy-duty construction, with a capacity of 8,000 lb., this unit has a base frame of square steel tubing integral with a steel plate which forms a smooth-surfaced pallet. Side panels of corrugated steel have corner posts of steel tubing which nest inside the legs of the skid to form a rack. Corrugated steel end panels are secured to the side panel corner posts through a self-locking device. These panels may be nested flat when the skids are returned empty, effecting a considerable space saving. Standard units measure approximately 3 ft. in width, 5 ft. in length and 40 in. in height. Depth of bin is more than 2 ft.

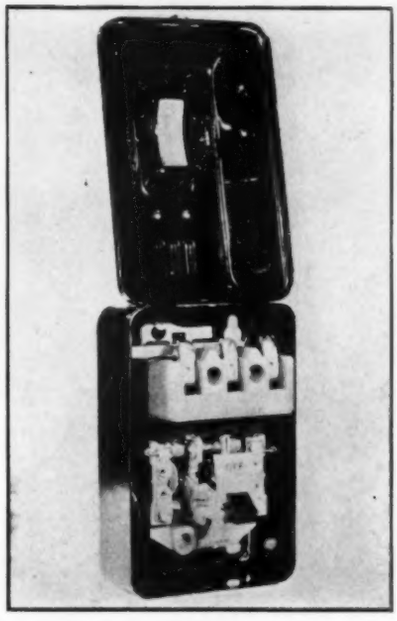
Square D Breaker Made in Small Size

Designated as the Type MO "Multi-BreakeR" and available in 15-, 20- and 25-amp. sizes, for 115 and 230 volt applications, a circuit breaker announced by the Square D Co., Detroit,

Mich., is suitable for use where Type D fusible switches previously have been applied. The unit is 6⅛ in. high, 4 in. wide and 2⅞ in. deep. It is adapted to flush or surface mounting. There are no exposed, live parts.

Westinghouse Starters Give Position Indication

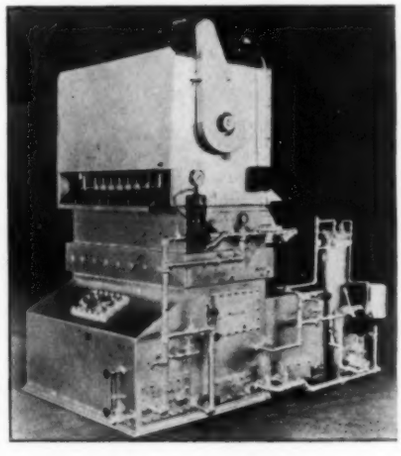
The "De-ion" manually-operated across-the-line starters developed by Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., for controlling grinding wheels, drill presses, fans, pumps, blowers, riveting and stapling machines and other electric drives, provide positive indication of on, off or tripped position by means of an indicating toggle switch recessed



within the cover to prevent accidental operation. A snap-action bi-metal disk gives accurate overload protection and automatically disconnects the motor from the line before heat can damage the winding. It is trip-free and cannot be held closed against continued overload. A safety interlock prevents accidental contact with live parts, since the cover may not be opened unless the switch is in "off" position.

"Detrex" Degreaser Fully Automatic

The Detroit Rex Products Co., 13005 Hillview Ave., Detroit, Mich., has developed a fully automatic vapor-liquid-vapor "Detrex" degreaser for the economical cleaning of cylindrically shaped parts, such as the stators and rotors used in electrical refrigerators. This degreaser fits into



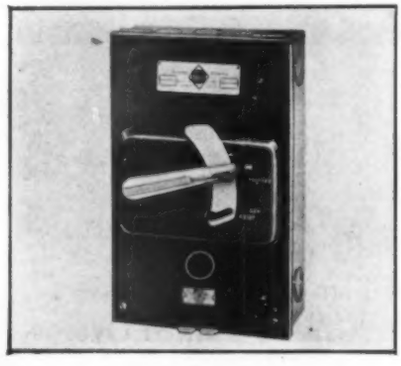
the manufacturing line, and does not require an operator to handle the work.

The conveyor on this machine is equipped with pendant fixtures for carrying the work to be cleaned. Work is fed to the degreaser six units wide from a table equipped with guides, and the parts are released by a chain-driven indexed feed mechanism which allows them to roll on the pendant-type fixtures; these fixtures being guided in both the loading and unloading positions.

The cleaning cycle consists of two minutes in vapor, two minutes immersion in boiling solvent, followed by two minutes in the pure solvent vapors. Work carried out of the vapors is clean, warm and dry. At the exit position the work is unloaded smoothly onto a platform as the conveyor changes direction of travel and tilts the work fixtures. Loading and unloading tables are at opposite ends of the machine. At a conveyor speed of 8 in. per min., this degreaser cleans 300 parts per hour.

Circuit Breakers Assure Industrial Protection

The latest addition to the electrical equipment manufactured by Colt's Patent Fire Arms Mfg. Co., Hartford, Conn., is the Type AB-I circuit breaker, designed to assure industrial protection and to eliminate expensive



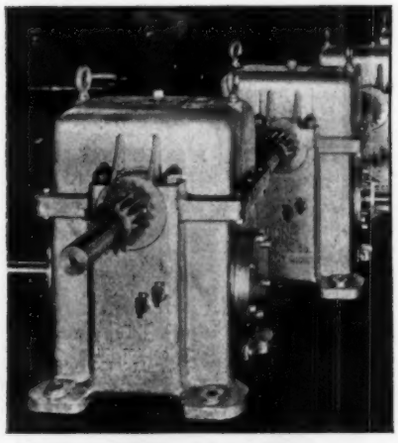
delays and time-out periods caused by overloads and short circuits. When installed and with the circuit open, the handle automatically indicates "tripped"; after the cause of interruption is removed, the handle is manually turned to "reset" and then to "on," and service is restored.

The breakers are furnished in a variety of types and sizes, with enclosures of sheet steel with grounded neutral, dust-resisting sheet steel, weatherproof cast iron, or an explo-

sion-resisting type. The sheet steel with grounded neutral enclosure is the most popular type of cabinet, and is equipped with a heavy hinged cover; a felt gasket to exclude dust; knockouts in the top, bottom, and sides; and a cover interlock.

Cone Area Worm Gears Save Space and Weight

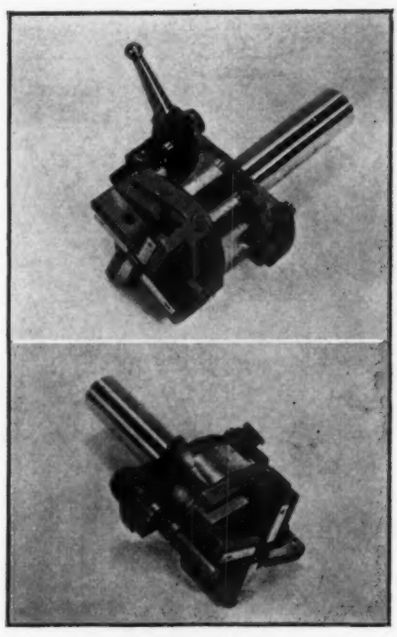
Covering the complete range of industrial capacities, a line of heavy-duty speed reducers incorporating the cone area contact type of worm gearing, offered by the Michigan Tool Co., 7171 E. McNichols Road, Detroit, Mich., makes possible important savings in size and weight. Increased tooth contact area is claimed to result in high efficiencies, while action of the gears, identical to that of the original generating tools, is said to increase gear life. Worms are of chrome-molybdenum-nickel steel and worm wheels are of nickel bronze. Anti-



friction bearings are used throughout, except for the sleeve bearings on the gear shaft of the largest units. Models range from 3 to 15½ in. center distance, with a wide selection of standard ratios for each size.

Flat Die-Head Chasers Can Be Turned Over

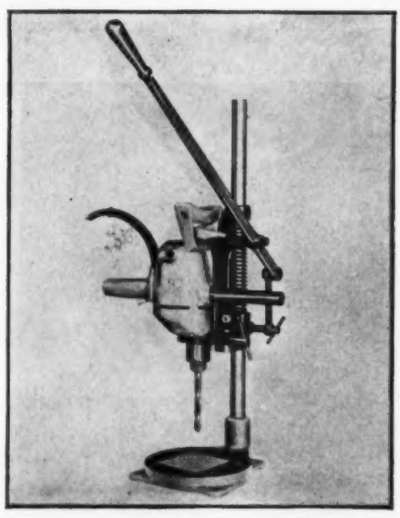
The Nos. 16S and 16SB die heads announced by the Jones & Lamson Machine Co., Springfield, Vt., are of the same general construction as the J & L "Tangent" dies except for the chasers which, although of the flat type, are equivalent in section to a tangent chaser. Both the top and bottom of the chasers are provided with chamfer and top rake. After they become dull on the top, they may be turned over, making them equivalent to two sets of ordinary radial type chasers. Each chaser is secured to the holder by a



single screw, which forces it against two ground surfaces. The chasers may be resharpened. The Model 16S die head, shown above, is designed for use on small hand screw machines. It is provided with an adjustable pull-off and a hank locking lever. The Model 16SB die head, shown below, has an external trip and is recommended for use on No. 0 and No. 00 Brown & Sharpe automatics. This die is so designed that it cannot open during the indexing movement on high-speed machines.

New Drill Stands Offered by Van Dorn

Two drill stands have been redesigned by the Van Dorn Electric Tool Co., Towson, Md., to accommodate several of the redesigned portable tools recently announced. The smaller No.

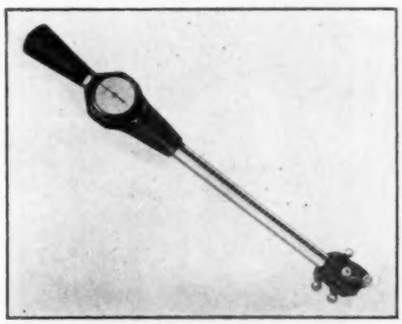


20 stand will accommodate the entire range of end-handle tools from the "Holgun" up to the ⅜-in. "Utility" drill, the "Scrugun," the No. 12 and No. 22 screwdrivers, and the No. 22 tapper. The lower clamp is adjustable for various spindle housing sizes, and the upper bracket is adjustable for various lengths of tools.

The No. 40 drill stand will accommodate the ½-in. "Utility" drill, the ⅝-in. "Heavy Duty" drill, as well as the ½-in. "Junior" and the ½-in. "Standard" drills. In this stand, the clamp bracket is adjustable for spindle size and it also slides up or down to accommodate varying tool lengths. This unit is available as a bench, post, or pedestal stand, while the No. 20 unit is available as a bench or post stand.

Internal Cylinder Gage Set Directly to Size

The Model 1200 cylinder gage announced by Federal Products Corp., 1144 Eddy St., Providence, R. I., will check the inside diameter, out-of-roundness and trueness of bores, such as automobile cylinders. This gage is set directly to size with micrometers



or against a master. Its method of positive location is based upon the geometrical axiom that three points not in a straight line define a plane. The three adjustable locating points are set at an equal distance which has a definite relation to the nominal diameter. These points locate the gage in relation to the cylinder wall and definitely locate the position of the measuring points perpendicularly to the cylinder's axis and diametrically across the cricumference.

Motion of the sensitive contact is transmitted to the indicator directly through a rod which is suspended by a flat spring and a bellows spring. There is no lever or bell-crank bearing to cause error, and no opportunity for wear. Two sizes are available, one having a range of adjustment from 2⅞ to 5 in. diameter; the other being adjustable from 5 to 10 in. diameter. Standard lengths from

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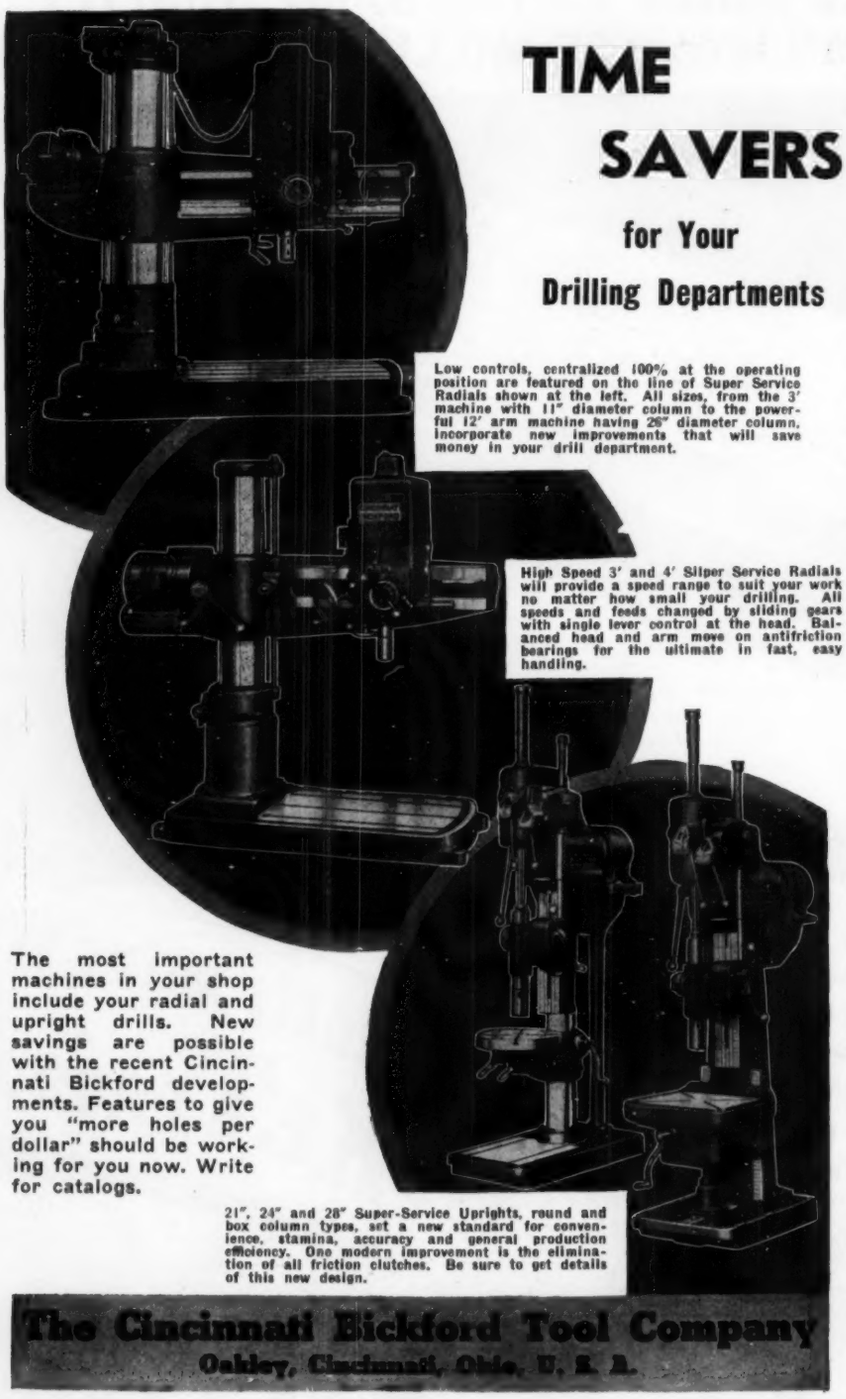
contact points to lower grip is 10 in. The standard indicator is graduated to 0.0001 in. and has a ± 0.005 in. range of reading.

Coatings Protect Magnesium Alloys

Development of three protective and decorative coatings for magnesium alloys has been announced by the Dow Chemical Co., Jefferson Ave., Midland, Mich. Two of these coatings, known as Treatment No. 7 and Treatment No. 8, are claimed to surpass other known treatments in protecting magnesium alloys against salt water, and upon general atmospheric exposure result in satisfactory adhesion surfaces for subsequent paint systems. Since they produce no dimensional change, these treatments may be used on parts machined to close tolerances.

Treatment No. 7 usually is applied to "Dowmetal" parts after they have been machined. It is said that all surfaces, even deep holes, treat equally well. The treatment imparts a dark brown to black finish on most alloys, and may be used on all except "Dowmetal M". It finds its principal application in the aircraft field. Treatment No. 8 may be used on all alloys and forms, including "Dowmetal M". This treatment does not affect machined dimensions and leaves machined surfaces with their original lustre. Complete treatment is obtained on all surfaces, including the bottoms of deep holes.

Treatment No. 6 is a protective coating by means of which various colors can be produced. In reality, this treatment is dye coating produced in water solutions at high temperatures and pressures. The coating can be furnished in colors ranging from yellow, red, blue and green, to metallic lustres such as bronze and brass. Its principal use is for decorative treatments and it may be used to protect parts which cannot be painted conveniently.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Tool Life Lengthened By "Nusite" Process

Adopted commercially by the Perfection Tool & Metal Heat Treating Co., 1740 W. Hubbard St., Chicago, Ill., the "Nusite" process of heat-treating cobalt high-speed tools is claimed materially to increase the toughness of this material, permitting heavier cuts and higher speeds, and lengthening tool life. The company is in a position to treat cobalt tools by this process, and can supply bits, flats and squares which have been treated by the Nusite method. The organization also tips large tools with cobalt high-speed steel tips which have been treated by the "Nusite" process.

Filter Press Papers Clean Plating Solutions

The Hanson-Van Winkle-Munning Co., Matawan, N. J., has placed on the market a filter press paper which offers a solution to the problem of clogged filter cloths when filtering electroplating solutions. At present the papers are furnished in $12\frac{1}{2}$ x $12\frac{1}{2}$ in. squares to fit a 12 x 12 in. Sperry filter press. Two holes are machine cut in opposite corners of the paper to line up with holes in the plates and frames. Other sizes can be furnished with holes cut to suit existing press equipment.

These papers are placed over the cloths when assembling the press, making certain that the flow of solution is through the paper toward the cloth. The paper thus catches all the suspended matter being filtered from the solution; the cloth simply acts as a support for the paper. When it is

necessary to clean the press it is opened and the papers with the collected sludge removed and discarded. As the paper is only 0.003 in. thick, it does not hold the plates away from the frames in the press. Good contact is maintained and the solution does not leak from the press.

Moly High-Speed Steel Does Not Decarburize

A "balanced" relationship between tungsten and molybdenum in its DBL tungsten - molybdenum high - speed steel is claimed by the Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh, Pa., to be responsible for the following properties:

1. Heat-treat in the same equipment and under the same furnace conditions as ordinarily used for 18-4-1 high speed steel. Borax coatings or special atmospheres are not needed. Ordinary high-speed steel hardening salt baths can be employed if desired. Machining and grinding tolerances are the same as for 18-4-1.

2. There is less segregation in the steel because of the balanced relationship between tungsten and molybdenum. The carbides are smaller, giving a fine-grained steel that better supports a fine cutting edge and wears longer. Small carbide size also assists toughness.

3. The cutting efficiency is improved. As a result of field reports, the corporation claims that the steel is a true general-purpose type tool steel. It is not claimed to compete with the highly alloyed types, such as those containing appreciable percentages of cobalt.

The analysis of DBL is: Tungsten, 5.25 per cent; molybdenum, 4 per cent; chromium, 4 per cent; vanadium, 1.50 per cent; and carbon, 0.80 per cent. The hardening range is from 2,200–2,300 F. Annealing is done between 1,500 and 1,600 F. Brinnell hardness after annealing should be 228 to 241. At this hardness the machinability is excellent in comparison with other high-speed steels. Hardening and tempering instructions are contained in a four-page bulletin now available.

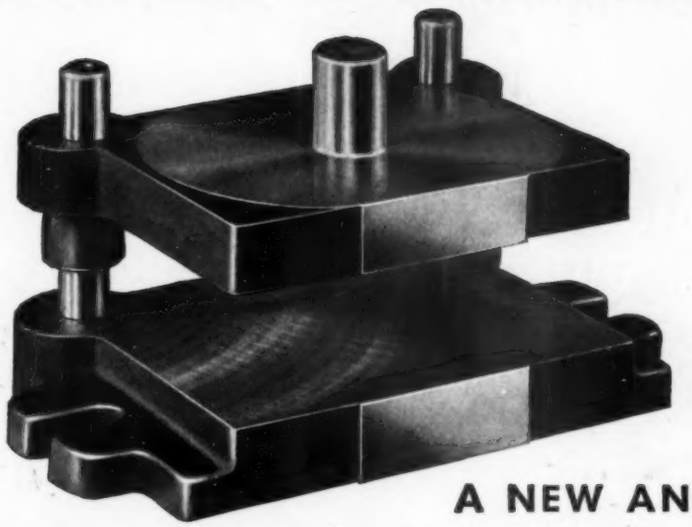
"Electrex" Cleaners Announced by Magnus

"Electrex" cleaners, developed for use in cleaning metal surfaces for electroplating or other finishes, are offered by Magnus Chemical Co., Garwood, N. J., in a graded series of electroplaters' metal cleaners based on the wetting agent known as "Saponex." This material has rapid wetting, penetrating and dispersive effects; providing more rapid and thorough cleaning. It is acid and hard waterproof, and can form no troublesome scum by "drag-over." It is free rinsing by reason of the low surface tension of its solutions. Succeeding rinses and dips are kept free of contamination.

This cleaning method is said to be particularly valuable before bright plating and usually eliminates any need of scouring. It is used at high concentration and high current density with reverse current. The work should be the anode (except with die cast metal, zinc, aluminum or other soft metals, in which case the work should be the cathode.) The usual electrocleaning equipment with steel tank and plate steel cathodes suffices. Best practice is to use cathodes of perforated steel, nickel plated.

Steel or copper surfaces can be cleaned completely in one electrocleaning operation, of polishing or buffing compounds, almost all drawing compounds, smut, finger marks, and shop dirt. Degreasing, precleaning, scrubbing or hand wiping opera-

DANLY *Announces*



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ENLARGED LINE OF PRECISION DIE SETS

Danly Precision Guide Posts are ground, and lapped to plus or minus .0001" of listed dia. Precision Bushings are ground and honed to plus or minus .0001" of listed dia.

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To meet the rapidly growing needs of the stamping industry, Danly Precision Die Sets are now available in a complete range of sizes of standard, back post sets for any die from 3"x3" to 16"x25".

Especially useful are a new square series, in sizes from 3"x3" to 14"x14".

The regular standard line has also been expanded, many new sizes added, and the line extended in the larger sizes.

If you have not received a copy of the new Danly Catalog, 10th Edition, which we believe is the most useful, easily used catalog in the industry, write for your copy.

Here you will find everything you need in standard die sets for the complete range of die requirements—and remember each size is stocked in each of the 8 Danly Branches for immediate delivery.

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tions are claimed to be unnecessary. Where the work is very heavily loaded with drawing, polishing or buffing compounds, the usual practice of two-tank cleaning is recommended.

TRADE PUBLICATIONS

CRUSHERS Bulletin No. 4939, issued by the Stephens-Adamson Mfg. Co., Aurora, Ill., discusses features of the "Knittel" ring-type coal crusher.

EXPANSION PLUGS Catalog No. 39, "A Better Anchorage for Bolts and Screws", published by The Rawlplug Co., 98 Lafayette St., New York, N. Y., contains 38 pages describing various types of bolt anchorages for use in wood, cement, fibre and similar materials.

FLEXIBLE COUPLINGS Bulletin No. 57, published by the Morse Chain Co., Div. of Borg-Warner Corp., Ithaca, N. Y., provides 32 pages of illustrations, description and engineering specifications concerning numerous types of flexible couplings.

An important addition to the MICHIGAN line of crossed axis gear-finishers • Completely hydraulic and automatic in operation.

Rapid approach • Adjustable cutting feed • Adjustable hydraulic-cushioned rack reciprocation • Adjustable transverse head reciprocation • Automatic sizing of gear • Automatic stop for rack . . . Automatic fast return.

Designed for mass production of gears at the lowest possible tool cost • Modernly streamlined • Completely flexible . . . New 6-stage coolant filtering system for even finer finish and longer tool life • Massive construction.

Capacity: Diameter gears up to 8 inch. Length between centers: 18½ in.

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GEARING Technical Data 71–000, now being distributed by Dept. 7-N-20, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., provides 16 pages of engineering data concerning the manufacture, application and maintenance of heat-treated hardened gearing.

GRINDING The Norton Co., Worcester, Mass., has published a 76-page booklet, "Facts about Grinding Wheels", which provides detailed information concerning grinding and grinding wheels, reference tables, and factors influencing wheel selection.

HEATING DEVICES Leaflet No. 11-TF, issued by the Harold E. Trent Co., 618 N. 54th St., Philadelphia, Pa., describes a line of industrial ovens and electrically heated kettles. Leaflet No. 20-TG describes a line of parts and trough-type electric furnaces.

HEATING UNIT Applications of several types of heating units to industrial equipment are discussed in Leaflet No. GES-2203, now being distributed by the General Electric Co., Schenectady, N. Y.

METALLIZING GUN The Metallizing Co. of America, Inc., 1351 E. 17th St., Los Angles, Calif., has prepared a 26-page booklet giving details on metal spraying and listing equipment necessary. Also available is a bulletin describing the company's new "Propane-Mogul" gun.

POWER TRANSMISSION Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill., provides 272 pages of design and application data concerning an extensive line of power transmission equipment in its booklet No. 1600.

ROLLER BEARINGS Specifications and engineering data concerning several standard types of tapered roller bearings are provided by a series of data sheets, supplement No. 1 to the Bower Engineering Journal, issued by the Bower Roller Bearing Co., 3040 Hart Ave., Detroit, Mich.

SAFETY A line of face shields designed to protect workers from dust, sparks, heat and glare is discussed in a bulletin released by the Davis Emergency Equipment Co., 55 Van Dam St., New York, N. Y.

SHEARS Bulletin No. 71-G, issued by the Niagara Machine & Tool Works, 637 Northland Ave., Buffalo, N. Y., includes illustrations

and specifications of the Series 10, 100 and 500 power squaring shears.

STEEL DATA An 8 x 15-in. chart giving the physical properties of nearly 50 different types of steel is now being distributed by Joseph T. Ryerson & Son, Inc., 16th & Rockwell Sts., Chicago, Ill.

TURBINES Information concerning the application and selection of steam turbines of up to 10,000 kw. rating is provided in a 48-page booklet, No. B-2198, issued by Dept. 7-N-20, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

TURRET LATHES Data Sheets Nos. 18, 19, 20 and 21, issued by the Gisholt Machine Co., 1201 E. Washington Ave, Madison, Wis., provide case studies of several types of operations performed on turret lathes.

VARIABLE PULLEY A leaflet offered by the Speedmaster Co., Division of Continental Machines, Inc., 1301 Washington Ave. S., Minneapolis, Minn., provides specifications of the "Speedmaster" variable-speed V-belt pulley.

VARIABLE TRANSMISSION A folder issued by the Reeves Pulley Co., Columbus, Ind., discusses the effect on machine tool performance of several types of variable speed transmissions.

VISCOSITY TESTING Bulletin No. 701, published by the Precision Scientific Co., 1750 N. Springfield Ave., Chicago, Ill., provides specifications of a new Saybolt Viscosimeter for determining oil viscosities according to method D 88 of the American Society for Testing Materials.

WELDING Anyone interested in building his own gas-engine welder will be helped by Booklet No. B-2205, issued by Dept. 7-N-20, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., entitled "Tips on Building Your Own Gas-Engine Welder."

WHEEL DRESSER The "Super Cardimond" manufactured diamond for dressing grinding wheels is described in a leaflet offered by the Super Tool Co., 21650 Hoover Road, Detroit, Mich.

WIRE MEASURING Catalog Section No. 3, issued by the Durant Mfg. Co., 1929 N. Buffum St., Milwaukee, Wis., provides specifications of a line of ball bearing heavy-duty wire measuring machines.

SEEN and HEARD

JOHN R. GODFREY

Ask the Man Who Makes Them

No matter how well we try to keep posted on the development of new materials and new methods, it pays to check up before deciding whether or not they are the best *now* available for our purpose. New plastics, new die-cast metals and methods may make them the best bet for that new product, or as new materials for an old part. It may save disappointment later if we get the latest information from those who make or fabricate the various materials.

Photos as Records

"Snapshooting" may be just another American disease but many shops find it convenient to keep a camera loaded for prompt use. Fast films make it easy to take out-of-the-ordinary jobs and methods for future use. Photos can show the condition of the machine, or part, as received

HERE'S THE BEST COMBINATION *for* MAXIMUM MACHINABILITY *at* HIGHER SPEEDS

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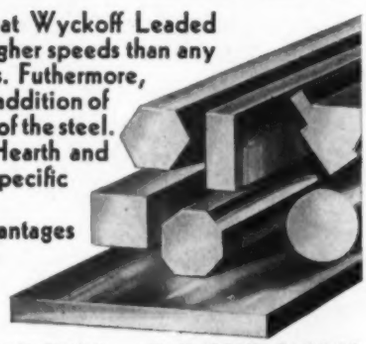
Production records prove conclusively that Wyckoff Leaded Steels will machine better and at much higher speeds than any of the well known standard analysis steels. Futhermore, it has been definitely determined that the addition of lead does not affect the physical properties of the steel.

All regular S A E grades, both Open Hearth and Bessemer Steel are available to meet your specific conditions.

Data covering the characteristics and advantages of these leaded steels will be gladely sent on request. Would you like to have samples for tests runs in your shop?



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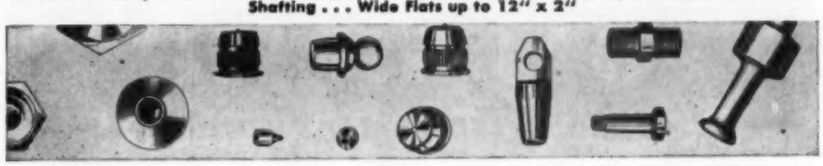

and as finished. Some shops find a record of this kind worth many times the cost. It's largely a matter of including it in the shop routine.

Profit Sharing

Profit sharing is again being proposed by some manufacturers as one of the readjustments in labor relations. One plan involves some such division as this: Payment of interest at six per cent on capital actually invested; moderate salaries to executives and a percentage sharing of profits, if any, on the basis of salaries.

Both boom years and lean years present a real problem. In boom years those who have risked their capital feel that part of the velvet should come their way, in addition to the six per cent. In lean years labor feels that it should be the last to suffer as its yearly income is much nearer to the subsistence line than either capital or management.

Labor usually agrees that management should receive a larger percentage of profit than it should. On the other hand it feels that lack of profit is usually due to the failure of management rather than of labor, so that management should take the first cuts. Many on both sides doubt that profit sharing can be made to work satisfactorily to either, except when there are profits to be divided. Employers seldom propose it. Now that some have done so, the whole question comes up again.

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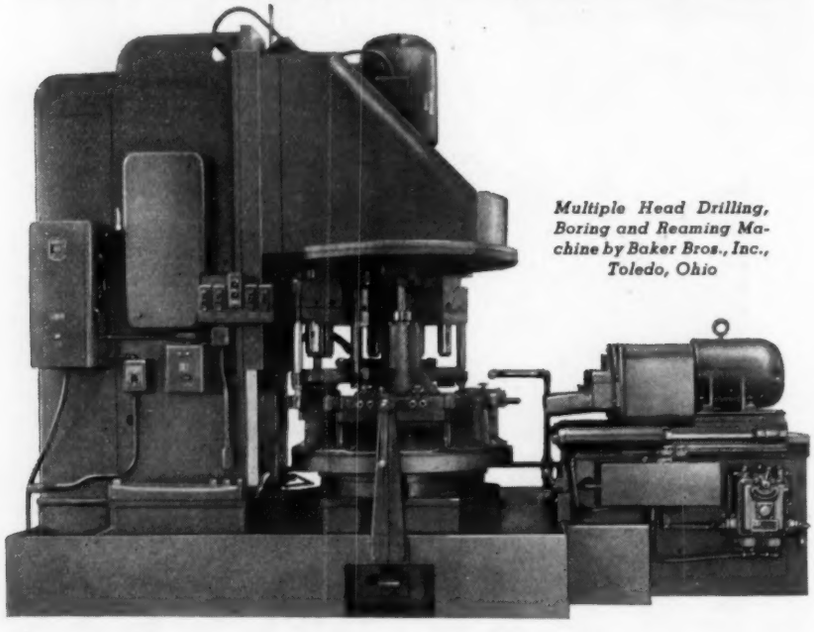

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NEW BOOKS

FORGING HANDBOOK—*By Waldemar Naujoks, chief engineer, The Steel Improvement and Forge Company, and Donald C. Fabel, head of Mechanical Engineering Department, Fenn College. 630 pages, 6 x 9 in. Indexed and illustrated. Clothboard binding. Published by the American Society for Metals, 7016 Euclid Ave., Cleveland, Ohio. Price $7.50.*

One of the oldest of the mechanical arts, forging has probably received less attention by technical writers than any other branch of metal working. This volume covers the entire forging field which includes design, processing, materials, equipment and tools. The data for this volume is drawn from a wide range of sources, including makers and users of forging equipment.

Some of the many phases of forging operation considered are plant equipment, die block operations, hammer practice, metal flow, heat-treatment of forgings, cleaning, testing methods, furnaces and furnace design, forging materials and job estimating.

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ARC WELDING IN DESIGN, MANUFACTURE AND CONSTRUCTION. *1408 pages, 5¾ x 8⅝ in. Limp leather binding. Indexed and illustrated. Published by the James F. Lincoln Arc Welding Foundation, P. O. Box 5728, Cleveland, Ohio, price $1.50 in U. S. A., $2.00 elsewhere.*

This volume is a compilation of 109 papers offered in competition during the $200,000 award program sponsored by the James F. Lincoln Arc Welding Foundation. A 32-page section at the front gives information regarding the foundation and the award, together with a list of authors and a table of contents.

The papers themselves are divided into ten sections corresponding to classifications in the prize competition. These were respectively automotive, aircraft, railroad, watercraft, structural, furniture and fixtures, commercial welding, containers, machinery, and jigs and fixtures. With few exceptions the papers are reproduced

in their original form; only when they were too lengthy for full inclusion are they given as comprehensive briefs. Photographs and drawings essential to the presentation of the subject are included.

The machinery section, for example, fills 382 pages and carries 190 illustrations. All in all, the studies provide a vast volume of information on welded design and fabrication.

•

ENGINEERING QUESTIONS AND ANSWERS—*Volume II. 176 pages, 7½x9¾ in. Indexed and illustrated. Paper binding. Published by Emmott & Co., Ltd., 28 Bedford St., London, W.C. 2, England. Price, 6 shillings, net.*

The questions and answers section of the "Mechanical World and Engineering Record" has been a feature of that journal for a great many years, and frequent requests have been made that the answers be published in book form. The outcome was the first volume of Engineering Questions and Answers, which contained a selection of answers which appeared during 1934 and 1935. The reception accorded the first volume has led to the publication of this second volume, which continues with answers published during 1935, 1936, 1937 and 1938. The answers cover questions arising on all phases of engineering work, both in the field and in the shop. No attempt has been made to segregate the different items according to subject, but the index aids in locating specific items.

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KNOW YOUR STEEL—*by Halfdan Halvorsen. Second edition, revised and enlarged. 109 pages, 3¾x6½ in. Flexible, loose-leaf binding. Published by H. M. Halvorsen, P. O. Box 63, Harper Station, Detroit, Mich. Price, $1.50.*

This enlarged pocket edition lists more than 650 trade names of the best known steels and tabulates recommended heat treatments for each. A convenient index aids in the use of this reference work.

Tool Life and Cutting Oils

BY C. G. WILLIAMS

In an article by J. T. Beard on this subject (*AM*—Vol. 83, page 111) there are several statements that are not substantiated in practice. It is an accepted fact among machinists that, no matter how much of a coolant one puts on a tool, it will wear rapidly from chip action and but little at the very edge from heat action. After the steel tool has had a crater worn in its top surface, it will cut smoother, easier and faster than it would before the crater had been formed.

There is another phase in cutting steels that must not be overlooked, that is the small mass of carbides that are built up on the point of the tool. This mass is never over $\frac{1}{64}$ in. wide and from $\frac{1}{32}$ to $\frac{1}{16}$ in. high, depending on the shape of the tool and the size of the cut taken. When this formation has been built up, and just as long as we can hold this false edge on the tool, there will be a reduced amount of power absorbed.

This phase is assisted and prolonged by the coolant that is flowed on the work. It is not believed that there is any lubrication of the point of the tool, nor of that part of the tool in contact with the chip, for the heat generated by the cutting action is so great as to vaporize the little coolant that may get onto this part of the tool.

The only work that can rightly be

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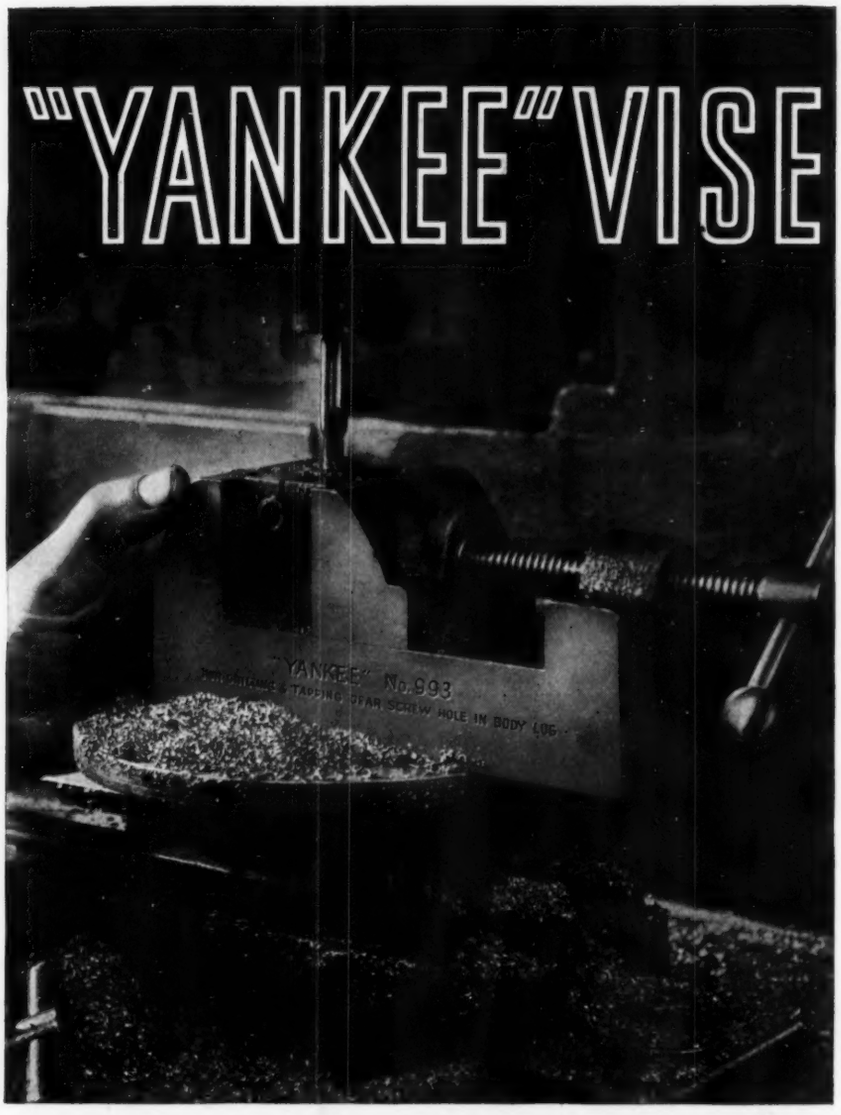

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assigned to the coolant, be it a soluable oil, cutting oil, sulphonated cutting oil, sulphur bearing cutting oil, yard oil, or what not, is to remove the heat from the tool and chip as fast as possible.

As the coolant does not get near the tip of the tool, where all of the heat is generated, it can only lower the heat at the point of the tool by conduction, convection and radiation. The fact that there is an oil in the mixture of so-called soluable oil would reduce the amount of heat carried away by convection. A plain soda or salt solution will carry away more heat units by convection than will the various solutions containing oils of any kind. A straight oil, such as the sulphur bearing oils, will carry away more heat units than will the soluable oil mixtures.

Mr. Beard says: "The chief function of cutting oils is to lubricate the cutting tool" and later on refutes that statement by another: "It is impossible to introduce cutting oils in to the cutting and rubbing surfaces after the tool has begun to cut." If the oil cannot get to the cutting and rubbing surfaces after the cut starts, how can the coolant lubricate the point of the tool, when the heat, pressure and friction of the chip is so great as to form a crater in the hardened cutting tool?

It has been noted in the use of carbide-tipped tools that if the coolant be directed in a heavy stream under pressure from the bottom of the tool, the tool is kept cool much longer than in the case where the flow of coolant is directed on top of the chip. In the ultra-fast action of cutting steels with carbides, the chip does not indicate extreme heat as soon as removed from the body of the work, but does show it after the chip has moved approximately ½ in. from the work.

In all steel cutting operations on lathes, the size of the crater varies according to the chip size, and to but a slight extent as to the hardness of the metal being cut. Chips from heat-treated metals always will erode a larger cavity in the tool if scale is left on the outside of the piece. If scale is removed by pickling, the cavity will be approximately the same size in all grades and hardness of steels, depending on the depth of cut, the feed and the speed. As the heat developed by cutting harder steel is much greater than is the case when cutting soft steels, the crater is developed much more rapidly. There is no difference in size or rate of formation of the crater whether a coolant is used or the metal is removed with the cutting tool absolutely dry.